DOCUMENT RESUME

ED 139 600 SE 021 309

AUTHOR Ozinonu, A. Kemal
TITLE Growth in Turkish Positive Basic Sciences, 1933-1966.
INSTITUTION Middle East Technical Univ., Ankara (Turkey).
PUB DATE 70
NOTE 87p.; Not available in hard copy due to copyright restrictions ; Financial support for this study provided by Scientific and Technological Council of Turkey
AVAILABLE FROM The Book Store, Middle East Technical University (ORTADOGU), Ankara, Turkey ($1.95)

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Foreign Countries; Higher Education; *Manpower Development; Manpower Utilization; *Research; *Science History; *Scientific Manpower; Scientific Personnel; *Scientists; Surveys
IDENTIFIERS *Turkey

ABSTRACT

This study collected data on the measurable qualities of Turkish science in terms of high level scientific manpower, scientific productivity, and scientific fertility from 1933 to 1966 and analyzed the data collected with the goal of providing a deeper understanding of the nature of Turkish science. Scientific personnel, including Turkish scientists abroad and foreign scientists who served Turkey during the period covered, in mathematics, physics, astronomy, chemistry, biology, and interdisciplinary areas, were surveyed. Research methodology, statistical design, findings, and results are detailed. Based on the results of this study, seven generalizations are drawn concerning the pattern of scientific development observed in Turkey beginning in 1933. (BT)

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GROWTH IN TURKISH POSITIVE BASIC SCIENCES, 1933-1966

Dr. A. KEMAL ÖZİNÖNÜ

Assoc. Professor

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ANKARA 1970. YAYIN / PUBLICATION NO. 17

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ACKNOWLEDGEMENT

To work with scientists was an exciting task — even though gathering data about them was not always easy. Knowing about scientific development of a nation requires knowing of scientists and the institutions of science. Knowing meaningfully about a nation's science undoubtedly leads to having some measurable qualities of state of science such as counting the heads of scientists and the younger scientists they had regenerated and the scientific papers they had produced.

The spark which inspired the present study on Turkish scientific development resulted from Professor Erdal İnönü's encouragement. Professor Derek Price gave valuable suggestions over the text and made available important literature necessary for international comparisons.

Scientific and Technological Research Council of Turkey provided financial support for the great part of the study for which I am greatful.

The data obtained resulted from the cooperation of the Turkish basic scientists who kindly responded the questionnaires and who gave their times for interviews. Many students of mine helped in transfering data from questionnaires into IBM cards. Mr. Abdurrahman Ş. Sanay from Ministry of Education Test and Research Bureau, and Mr. Ismet Güngör from IBM center of METU gave their valuable times for writing and checking the IBM programs.

Last, but not the least, I am greatly indebted to my wife Mrs. Lamia Özinönü who patiently assisted me in every stage of the study from data collection to proof reading of the text. My gratitude goes to those who assisted, but errors and shortcomings are only mine.

It is my only hope that the present study will shed some light to the formulation of science policy of Turkey which, as the results of the study suggest, needs both short and long term planning. Equally, I do hope that the study will serve as a source for further studies related to scientific manpower and higher aducation in Turkey.

Ankara, 1970 A. K. Özinönü

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GROWTH IN TURKISH POSITIVE BASIC SCIENCES, 1933-1966

Assoc. Prof. Dr. A. Kemâl ÖZINÖNÜ

Ö Z E T

1933-1966 Devresinde Türkiye'de Bilimsel Gelişmenin Yönelimleri

I. PROBLEM VE KAPSAM

Bu çalışma esas olarak 1933-1966 yılları arasındaki son otuz üç yıllık devrede Türkiye'deki bilimsel gelişmeyi bilim adamları ve bilimsel yayınlar sayısındaki artış ve artış hızının yıllar itibariyle gösterdiği eğilimleri ortaya koymayı ve böylece Türkiye'nin, gelişmiş ülkelerde gözlediğimiz gelişmeye benzeyen üstel bir gelişme yönelimine ulaşıp ulaşmadığını tespit etmeyi hedef olarak almıştır.

Belirtilen bu ana gayenin yanı sıra incelemede, Türkiye'nin bugünkü bilimsel potansiyeli temel bilimler (fizik, kimya, matematik, biyolojik bilimler, astronomi ve disiplinler arası ihtisaslar) alanları ve araştırma ve yetiştirme kurumları itibarıyle ele alınmakta ve Türkiye'nin bilimsel gelişmesine dış memleketlerdeki eğitilme, yabancı ziyaretçi profesörlerin yetiştirmeleri şeklinde beliren yabancıların katkısı ve bu katkının tarihsel oluşum içerisinde gösterdiği değişmeler; çeşitli akademik kademelerde düşey geçiş süreleri; yetişme - yetiştirme arasında geçen zaman ortalamaları; Türklerin yetiştirdiği ilk Türk bilimadamları; bilimsel insangücü piramidinin gösterdiği nitelikler; araştırma ve yetiştirme kurumlarındaki tarihsel gelişme ve etkileşim; türlü disiplinlerde yetiştirme durumlarıyle yetiştirme kurumları arasında insangücü «input-output» ilişkileri; bilimsel gelişme, bilimadamı, nüfus ve Gayrı Safi Millî Hasıla arasındaki ilişkiler istatistik verilere dayanılarak yapılan analizler sonucunda ortaya konmakta ve bu sonuçlar diğer memleketlerin gösterdiği durumlarla karşılaştırılarak bazı genel hükümlere varılmaktadır.

Araştırmanın ağırlık merkezini Cumhuriyet devrindeki bilimsel gelişme teşkil etmekle beraber, Osmanlı devrinde temel bilimlerin durumu, tarihsel bir oluşum içersinde kısaca gözden geçirilmekte ve Osmanlı ilminin gösterdiği nitelikler Avrupa'da ayni devirde yer alan bilimsel gelişmelerle karşılaştırılmaktadır.

II. METODOLOJI

Araştırmada uygulanan metod önce verilerin toplanması, sonra bunların IBM kartlarına aktarılarak aşağıdaki istatistiksel analizlerin yapılması şeklinde özetlenebilir. Uygulanan başlıca istatistiksel analizler şunlardır :

1. Bu araştırmanın maksadına uyması dolayısıyle temel bilimlerde en az doktora yapmış ve böylece en az bir yayını bulunan her kimse «bilim adamı» olarak nitelendirildikte, türlü bilim dallarında ihtisas yapmış bulunan ve dört grup halinde sınıflandırılan bilim adamlarının yıllara göre tespit edilmiş frekans ve yığmalı frekans dağılımlarının grafikleri hangi nitelikleri ortaya koymaktadır? Doktoralı ve Türkiye'de görev yapan bilim adamlarının otuzüç yıllık gelişmesi frekans ve yığmalı frekans dağılımları olarak ifade edildikte bu gelişmenin nitelikleri nasıldır? Ayni şekilde, doktoralı Türk bilimadamlarının, doçent ve profesör seviyesindeki bilimadamlarının sayılarında son 33 yılda nasıl bir gelişme olmuştur?

2. Bu dört grup için yapıldığı gibi, türlü disiplinlere (örneğin : fizik, kimya) mensup bilimadamlarının sayılarında son 33 yılda meydana gelen gelişme disiplinler bakımından nasıl farklılık göstermiştir?

3. Dört guruba mensup (örneğin : doçent, profesör) bilim adamlarının frekans ve yığmalı frekans dağılımları araştırıcı ve yetiştirici kurumlar (örneğin : İstanbul Üniv. Fen Fakültesi) itibarıyle nasıl farklılıklar göstermiştir?

4. Toplam ve akademik kademeleri temsil eden dört guruba mensup bilimadamları sayısında gözlenen ve yığmalı frekans dağılımı şeklinde ifade edilen gelişmenin «en küçük kareler» yoluyla elde edilen teorik gelişme denklemleri (doğru ve eğri denklemleri) nelerdir?

5. Gözlenen verilere dayalı gerçel denklemler, üstel bir fonksiyon göstermesi gereken teorik gelişme denklemlerine ne değin uygun düşmektedir? Eğer teorik ve gerçel gelişme eğrileri arasında bazı farklar varsa, yani gözlenen gerçel denklemler teorik denk-

lemlere uygunluk göstermiyorsa, gözlenen bu farklar tesadüf sınırları içersinde midir yoksa istatistiksel olarak bir anlam göstermekte midir? (Bu analiz için Kolmogorov-Smirnov Manidarlık Testi uygulanmıştır).

6. Bilimsel yayınlar tür ve akademik kademeler, yerli ya da yabancı dergilerde yayınlanmış olmaları bakımından nasıl gelişme göstermiştir?

Bütün bu analizler sonucunda elde edilen bulgular ayrı ayrı tablolar halinde verilmiş ve Türkiye'ye ait bu bulgular diğer memleketlere ait bilgilerle karşılaştırılmıştır.

III. BULGULAR VE SONUÇ

Bu araştırmada elde edilen bütün bulguları böyle bir özet içersine sığdırmak mümkün olamıyacaktır. Bu bakımdan aşağıda sadece pek genel nitelik gösteren bulgularla bunlara dayalı sonuç ve karşılaştırmalar verilmiştir :

1. Bilim bakımından daha fazla gelişmiş bulunan batılı ülkelerle, bilimsel gelişme yönünden ilk temaslar hem Osmanlılarda hem de Japonya'da hemen hemen ayni devirde (1830'larda) ve batı ilmini tercüme şeklinde başladığı ve Japonya kendi bilim adamları rehberliğinde ilk Japon bilim doktorlarını daha 1888 de yetiştirdiği halde, bu sonuca Türkiye'de ancak 1949 - 50'lerde ulaşılabilmiş ve Osmanlıların temel bilimler yönünden Batıya dönüş hamleleri, Osmanlılarda bilimin izole edilmiş ve dağınık yapısını olumlu olarak etkilememiştir.

Bilimsel gelişme yönünde ilk düzenli adım, bu tür gelişme için ön şartlardan olan laisizmin hiç değilse hukuki olarak Türk toplumunda gerçekleşmesinden sonra 1933 yılında uygulanmaya koyulan Üniversite Reformu ile atılmıştır.

2. Bilimsel gelişmesinde Türkiye'nin izlemekte olduğu yönelim, batının kendi bilimsel gelişmesinde izlediği yönelimin safhalarını aynen göstermektedir ki bu : Bilimsel yönden üstün ülkelerde Türklerin eğitimi ve bu ülkelerden ziyaretçi bilim adamının Türkiyede görevlendirilmesi → İlk Türk bilim doktorlarının yetişmesi → Türkler tarafından yetiştirilen bilim doktorlarının kritik bir büyüklüğe ulaşması → Nitelik yönünden uluslararası makbul bilimsel standardlara ulaşma → Gelişme bakımından üstel fonksiyona uyma ve kalkınma safhalarını kapsamaktadır.

Türkiye bu günkü durumuyla kritik büyüklüğe ve uluslararası makbul bilimsel standardlara (araştırma ve yayın yönünden) ulaşma çabası içerisinde gözükmektedir.

3. İkinci Dünya savaşı ile negatif etkilenen Türk Bilimsel Gelişmesi bilimadamı sayısının 1933 - 39 devresinde ortalama olarak yılda 8, 1952 - 66 devresinde ise ortalama olarak yılda 17 fazlalaşması şeklinde bir yönelim göstermiş ancak, gelişmiş memleketlerde gözlenen üstel bir fonksiyona henüz ulaşamamıştır.

4. Bir yönü ile bilimadamı sayısındaki artışlar şeklinde ifade lendirdiğimiz bilimsel gelişmenin Türkiye'deki gelişiminin, üstel bir fonksiyona uyabilmesi için 1966 toplamı 420 olan bilimadamı sayısına aynı yıl sonunda 42, 1967 sonunda 47, ve İkinci Beş Yıllık Planlı Kalkınma devresi sonu olan 1972'de ise 75 yeni bilimadamı katılması zorunludur ki bu başlangıç devresinde (1966) yıllık bilimadamı artışının iki katına çıkarılmasını öngörmektedir.

5. Beklenen üstel fonksiyon gelişimine bilimadamı sayısı yönünden ulaşması mümkün olduğu zaman bile Türkiye'nin bilimsel gelişmenin öngördüğü nitelik şartını da gerçekleştirmesi zorunludur ki bu ise, yetiştirdiği her 9 bilimadamından 8'ine uluslararası makbul araştırma niteliği kazandırması anlamına gelmektedir. Çünkü mevcut bilim adamlarımızın ancak dokuzda biri uluslararası makbul nitelik gösteren bilimsel dergilere bilimsel nitelikteki makaleleriyle katkıda bulunacak güçte gözükmektedir.

6. Araştırma, yayın ve bilimadamı potansiyelimizin büyük ölçüde yabancı memleketler ilminin ve ilim adamlarının etkisi sonucunda meydana geldiğini ortaya koymuştur. Şöyle ki, temel bilimlerdeki doktoraların yüzde on beşi dış memleketlerde yapılmakta, geri kalan yüzde seksen beşin yüzde otuzaltısı yabancı profesörlerin rehberliliğinde yaptırılmaktadır. Ancak bu yönelim eski üniversitelerde zayıflarken yeni kurulmuş üniversitelerimizde kuvvetli olarak kendini göstermektedir.

7. Yeni kurulmuşlar dışında kalan üniversitelerimizde mevcut bulunan kürsü düzeninin yetiştirme fonksiyonu üzerinde negatif etkisi olduğu, doktora eğitiminin büyük çoğunlukla kürsü profesörleri tarafından yürütüldüğü ve kürsü profesörleri olmayan temel bilimler profesörlerinden yüzde kırkının hiç doktora yaptırmamış olmasının ortaya çıkmasından anlaşılmış bulunmaktadır.

8. Amerika'ya kıyasla Türkiye'nin doktora alma - doktora yaptırma süresi iki katı daha uzun bulunmuştur. Bunun en basit an-

lamı şudur ki Türkiye'de doktora yaptıranların sayısı iki katına ulaşıncaya kadar Amerika'nın bu potansiyeli 4 katı artmış olmaktadır.

Genel olarak Türkiye'de temel bilimlerde doktora ile profesörlük kademesine geçme, yani doktora yaptırma durumuna ulaşma arasında median yıl 17 - 18 olduğu halde Amerika'da bu süre 8 - 9 yıl civarındadır.

Sonuç olarak denilebilir ki bu araştırma, Türkiye'nin bu günkü bilimsel potansiyelini ve bu potansiyele ulaşmak için geçirdiği tarihsel oluşumu istatistik verilere dayanarak ortaya koymak suretiyle bilimsel gelişmemizi analizlemekte ve bu sonuçlara ulaşmamıza sebep olan sosyo - politik ve ekonomik kuvvetlerin tanınması yönünde yapılacak daha sonraki çalışmalar için bir kaynak ortaya koymaktadır.

I

INTRODUCTION

The widening awareness of the significance of knowing the nature of human resources to judge the level of economic and overall development of a society has led to the exploration of the growth of manpower in a more intensified manner especially during the last two decades. Many countries established manpower policies based on such thorough investigations. LEBERGOTT [1] investigated supply and demand equilibrium in manpower growth (growth of labor force) between 1800-1960. GINZBERG [2] discusses the importance of human resources and investment in people for a balanced economic development in a highly industrialized country like America, and investigates ways of estimation of the size of labor forces for the future [3]. Along the same line LESTER [4] exposes aspects of manpower planning including forecasting future demands, and economics of manpower planning, the influence of mobility and education in supplying of manpower.

Such studies carried out by OECD reviewing national science policies in OECD countries such as France [5], United Kingdom and Germany [6] and Belgium [7] deal mostly with aspects of present situation in science including governmental policy, education and science policy, science policy and the economy, research and science policy of those particular societies. With the exception of investigation of national science policy of France where some statistics dating back to 1928 which is concerned with the change occuring in scientific manpower pyramid was available, no analysis was made on the past trend covering the period before World War II on the subject of growth in scientific manpower at Ph. D. level. The data on scientific manpower of France will be later compared with that of Turkey. OECD countries also investigated the problem of financing of science and science education [8], and also research and development efforts in Western Europe, North America and the Soviet Union in comparative manner [9, 10] without providing any analysis of past trends in scientific manpower development. Along the same line a thorough investigation was made by National Council of Science Policy of Belgium exploring scientific potential of that country in 1961 by

means of a survey made on scientists and engineers employed by the education, public and private sectors. The scientists in the study were grouped with respect to their field of specialization as (a) scientists in exact sciences, (b) in social sciences and (c) in these sciences. Engineers are included in the first category in this study. Mediterranean Regional Project Studies on the other hand while investigating the present situation and the past trends, analysed changes occured in school enrolments school age population, teacher student ratios in the three levels of education, gave no reference to the trends in the development of scientific manpower at Ph. D. level.

The significance of knowing the present potential and past trends of graduate education in general and graduate education in pure exact sciences' in particular is very acute when one recognizes the dependence of future development of a country on science and technology. As a result of this need that this study was planned and carried out. Although the problem had already been attacked by some advanced countries, no such attempt has yet been made however in the developing or underdeveloped countries especially with respect to the exploration of the past trends in scientific manpower development. Among the studies dealing with the aspects of graduate education in the U. S. the studies of Grad[illegible] Hollis [illegible], Horton [illegible], Hughes [illegible], Ford [illegible] Education Association) [illegible], Walcott [illegible] are worth mentioning. The aforementioned citations may reveal that the studies concerning science and technology and their implementations and applications which appear in the international literature are far too numerous to be mentioned individually and too varied in nature and quality and in breadth and scope. It thus seems to be practical, at least from the point of view of the present research to classify them, even if it be in a global and general manner, with respect to the purpose that they seek to achieve by giving a few illustrative examples.

One group of studies attempts to explore the nature of science which is termed as studies on «science of science» such as those of Price.[1]

(*) In the light of the recent advancements in science, strict classification of sciences as exact sciences and descriptive sciences may be questioned. For the purpose of clarity however, I used the term in its old connotation.

(**) At the time when this study was conducted, A. B. Zahlan, from Beirut American University was working on a study aiming to investigate the case of Arab Countries.

Other investigators have dealt with the problem of science policy (e.g. OECD publications[22]) along others (e.g. Don Price and Schrader) which fall in the same category yet are primarily concerned with a deeper understanding of the nature of social and political processes through which a certain policy of science or technology has come into being.[23, 24] Another group of studies deal with the institutional development taking place in the structure of a scientific milieu[25, 26] while others give special account for one facet of the problem such as scientific and technical manpower[27] or the brain-drain[28] or the relations of science and technology to education[29, 30] to social change[31, 32] and impact of society on science[33] or economic aspects of science and technology.[34, 35] The multiplicity and variability of the available studies in this area may serve as criteria, even if not the best ones, to judge the complexity of the problem of science of science and scientific development.

For us, two categories of the studies mentioned above, that are science of science and the relations of science to education, are crucial because, the very nature of the present investigation has close bearings to both the exploration of growth of science in Turkey from a historical perspective and relations of this growth to the education of Turkish scientists.

While the problem of scientific growth at national levels has been investigated very widely yet with little or no emphasis on arriving at a reliable universal model, how science grows[36] of such few attempts as that of Price (Derek) — studies concerning scientific development of Turkey even at policy formulation level, are quite rare, if not nonexistant.

There are few but fundamental case studies covering the history of science in the Ottoman era[37] and Islamic period[38, 39, 40] which shed light on how science changes by providing us historical evidences on individual cases given in a chronological manner. Studies covering recent times, especially the period following 1960 Revolution are mostly policy reports which reflect the government's or TBTAK's activities in science[41, 42, 43] Okyar on the other hand, examines the problem of brain-drain of medical personnel from Turkey[44], and also legal aspects of training of Turkish students of science abroad.[45]

Aspects of education and changes in the system of education have been very extensively elaborated by many authors (e.g. Unat[46]), changing characteristics of Turkish education by Bursal

oğlu [47] and impact of social transformation on education, on Turkish value systems including changes in values related to science, technology and secularism by Kazamias [48], Berkes [49] and Levonian.[50]

II

PROBLEM AND PURPOSE OF THE STUDY

The crucial question why there are so many studies carried on the problem of science and tecnnology in our times may receive a justifying answer when one considers a rather high correlation between economic development of a nation with its high calibre scientific and technical manpower.[51] Likewise, observing and tracing that those nations which have enough number research front scientist have a greater change to explore the possible directions of technological innovations and progress than those which are much belower than their required quato of research front scientists will also add to the recognition of the importance of knowing more about science.

The first requirement for arriving at such an understanding and knowledge on science is the availibility of data on science. What data does one need for such an inquiry are nothing but statistics on measurable traits of science. Therefore one needs to know ways of measuring the product —acknowledging that quality can be equalized— and the producers of science. The product of science is the publications of scientists whilst the product of technology is patents. The producers are the scientists who publish in an acceptable quality. The measure of quality may be determined by some nationally, or better, by some internationally acceptable or recognized set of criteria. Closer or identical the national criteria to judge the quality of the product of science to international criteria, the more of the national product is scientific. This is so, because science is supranational [52] and has universality. If the product is not internationally recognized, it tends not to be scientific because it would never have a chance of being shared by the others concerned and thus doesn't add to the existing core of science, and likewise woud not be receiving from the existing body of science which is common for all scientists. Therefore, the product to be measured should be such to possess the quality of universality, and in the practical terminology that product should be nothing but research papers which appear in the leading journals of science of the world. Many of the

papers, meeting the norms of national journals may lack this international quality simply because these journals may not be referenced internationally and thus they have no chance to be included in the communicated part of body of knowledge which happens to be scientific knowledge.

On the other hand, counting the heads of the producers of science may regarded as a reliable measure of science simply because they are the sources of product constituting the body of scientific knowledge, provided that their product is shared by the population of the other producers of science. In addition, the product of the producer may be not only in the form of research papers which identifies the degree of his productivity but may also be in the form of new scientific manpower which the scientist may train through his keen advisorship. This latter type of product may be termed as the «fertility» of scientist. Needless to state that, due to differences in the criterion attributes in defining scientists, the measures on this dimension of science do expose some difficulties in direct international comparisons. Despite this shortcomings, data concerning scientific personnel proved to be useful in understanding the growth of science at national levels.

Training and education of scientists as well as the duration they spend in different levels of academic hierachy existing in universities are also our concern especially when the problem is investigated in terms of feedback that the institutions receive.

Knowing about science is not at all a new endeavour. Historians have concerned themselves in the history of science ever since history established itself as an independent discipline of inquiry. So are the philosophers. The attempts of knowing sociology of science [53] and psychology of scientists [54] are rather new demensions of science of science and are yet at a stage of an early beginning. Although knowledge concerning history of science is rather old, the knowledge concerning nature of scientific growth and behaviors of science is only as much as 30 - 40 years old.[55] This rather late development of the new discipline called «science of science» basically is due to the lack of data based on the aformentioned measurable qualities of science.[55, 56] Increased interest in science and technology among the political and military organization has resulted in piling up enormous amounts of data concerning scientific manpower, publications and expenditure on science during the period which began right after the war. The use of computers easing ways of tabulation and calculation of accumulated data has led to inceased accuracy and to time

saving. The need of knowing more about their scientific resourfulness made the governing bodies of both free-enterprice and centrally planned societies to pile more data on almost every aspect of scientific endeavour. The underdeveloped societies became aware of, if a bit with time lag, the importance of such data, especially when they underwent a semi-planned period. Turkey is a society of among this last group of nations.

In broader terms, it is then the main aim of the present study to collect data on the measurable qualities of Turkish science in terms of high level scientific manpower,* scientific productivity and scientific fertility from an earlier date (1933) up to present time (1966), and analyze the data collected for a deeper understanding of the nature of Turkish science.

Collecting data, due to the reasons exposed earlier would be the first and primary step of the study, since no such reliable data were available at the time when the study was planned and conducted.

It is hoped that by providing data of development over the past thirty-three years reliable answer to the following questions may be arrived at:

1. How has the number of Turkish scientists in basic disciplines varied between the years 1933-1966?

(a) What is the nature of such variability for each of the basic science areas investigated? (b) How does scientific personnel development vary in different faculties of science in Turkish universities? (c) How far does personnel development in Turkey adhere to a theoretically normal development of scientific personnel? (d) What is the doubling period for Turkish scientific personnel development? How does the doubling period vary in different areas of basic sciences and within different academic levels of basic scientists?

2. What is the length and nature of the formal education of Turkish basic scientists and the length of their services within each academic rank?

(a) What is the average length of education for B.Sc., M.Sc., and doctoral degrees and how do these averages vary from one institution to another?

(*) Throughout the paper the term «scientific manpower» is used synonymous to «scientific personnel» which, for the purpose of this study, means the sum of a high level scientists at any time within consideration. And «scientist» here connotes the producer of basic sciences who published at least one scientific paper including his Ph. D. or Doctorate dissertation.

(b) How do the averages change for each of the basic sciences investigated?

(c) What is the average length of time for academic promotion? How does this average vary for different institutions and each of the basic sciences investigated?

3. What is the average number of young scientists (e.g. new Ph. Ds) trained by senior scientist (e.g. professors)? If this average is defined as the «regenerating power» of senior scientists, how does the «regenerating power» vary by institution and area of science investigated? Is there a correlation between the regeneration power and the nationality of the senior scientist?

4. As measured by number of publications, what is the «degree of productivity» of Turkish scientists within the period covered in the study? What is the average number of research papers published in all the areas of science under investigation by all scientists? How does the average change for different ranks of scientists and for different disciplines? How do the averages vary with translations, textbooks, original essays and eclectic monographs?

5. As measured by the number of scientists engaged in various fields, what are Turkey's present resources in the basic sciences?

Because of the lack of data for earlier periods, only the past thirty-three years of Turkish scientific development were investigated. The year 1933 was chosen because of its significance as the date of the University Reform Act, enacted after the establishment of the Republic. Since part of the data were collected in late 1966, and the other part in early 1967, the year 1967 was taken as the cut-off point in calculating the duration of academic training and services of scientific personnel. Only scientific personnel in mathematics, physics, astronomy, chemistry, biology, and inter-disciplinary areas were included. Turkish scientists abroad and foreign scientists who served in Turkey during the period covered were also included in the data wherever possible. The survey included a wide range of scientific personnel, beginning with assistants and ending with professors who served at Turkish universities and business organizations. Emphasis was laid however, on data concerning scientists in universities.

III

METHODOLOGY AND STATISTICAL DESING

In the first stage of the study a short survey was made to explore the nature, availability and ways of securing the required data. In this preplanning period some institutions related to basic sciences were visited and scientists were consulted. Following this preliminary investigation, two questionnaires were designed: one for scientists at present working in Turkey, and the other for foreign scientists who had worked in Turkey and for Turkish scientits working abroad. The first questionnaire (Appendix 1) included (a) personal information, (b) educational qualifications, (c) academic qualifications, (d) publications and research, and (e) training aspects of Turkish basic scientists. The second was a condensed version of the first questionnaire and emphasized aspects of education. publications and regenerating power of scientists.

The questionnaire. with a list of areas of specialization coded for IBM processing is attached. The classification of the basic science fields was adapted from the National Science Foundation Classification of Basic Sciences and included general (e.g. mathematics) and specific (e.g. number theory) areas of specialization to be marked by Turkish scientists. An open end question for every general field of specialization was also included. Thus each scientist was identified by a code number referring to his institution and area of specialization. The code numbers were then grouped, regrouped and processed according to the demands of the study and within the frame of the statistical model designed.

The questionnaires were mailed, and those who had not responded were visited and interviewed by the investigator. Then the archives of the Ministry of Education and the universities concerned were investigated for purposes of cross-validation and completing the data.

The compiled data were put on IBM cards to be processed according to the statistical design described below:

1. For the purpose of this study, basic scientists were defined as being those engaged in basic sciences and holding at least a doctorate degree. Thus, individuals without doctorate degree engaged in basic sciences as university asistants were not included in our classification of scientists, although they were sent questionnaires and some data were also collected about them. They were omit-

ted because individuals in this group have not yet committed themselves to a scientific career, so there were significant fluctuations in their number from one year to the next.

2. With respect to scientific manpower development in the basic sciences, the scientists investigated were grouped as follows:

Group A: All scientists with at least doctorate degree.

Group A : An alternate form of Group A which includes Turkish scientists only.

Group B: Scientists in an academic career with at least doctorate degree.

Group C: Scientists in an academic career at associate professorial (docent) level.

Group D: Scientists in an academic career at professorial level.

Each of these four groups were divided into sub-groups according to their area of specialization. Thus, twenty four sub-groups were obtained in the following manner:

For Group A

Sub-group 1	all scientist with at least a doctorate in	mathematics
Sub-group 2	» » » » » » »	physics
Sub-group 3	» » » » » » »	astronomy
Sub-group 4	» » » » » » »	chemistry
Sub-group 5	» » » » » » »	biology
Sub-group 6	» » » » » » »	inter-disciplinary areas.

The same process was repeated for the other three major groups. Moreover, **Group A** was divided into sub-groups with respect to the institutions from which the scientists received their doctorate degree. In this classification another nine sub-groups were obtained. **Groups C** and **D** were similarly sub-divided.

3. Scientists in **Group A** were investigated for training; **Groups B, C, D,** and some secondary important groups corresponding to other academic ranks (e.g. instructors) were investigated for length of service.

4. **Groups B, C, D,** and a group of instructors were classified by their research and publications.

5. Only the groups of associate professors and professors were examined for rate of regeneration of new scientific manpower.

6. For the above groups and sub-groups the following statistical treatment was employed: (a) Averages of training and length of service were calculated for the sub-groups of area specialization; for institutions served; and for academic rank sub-groups. (b) The size of each group and sub-group with respect to their universe was tested for significance of representation. (c) A frequency (f = increase in number of scientists in three year periods) and cumulative frequency (cum f = total number of scientists) of the total scientists and the scientists in different sub-groups were compiled for a period of thirty-three years of development. (d) The procedure used for (c), with the exception of academic rank sub-grouping, was repeated for scientific manpower attached solely to universities. (e) Theoretical equations of scientific growth were obtained for the total number of basic scientists and for scientists in some sub-groups. (f) The levels of significance for «goodness-of-fit» of the observed frequencies to the theoretical distributions were found by the Kolmogorov-Smirnov (KS) Test of significance. (g) Also examined was the growth of scientific research as measured in terms of scientific papers published in physics during the period covered by this study.

Most of the data was processed by IBM, and mathematical operations related to curve fittings were done on a calculating machine.

The data concerning publications in basic sciences were checked and supplemented by the available bibliographic sources.[7]

IV

FINDINGS AND RESULTS

The study's findings are presented under three groups. The first considers aspects of the present situation in the basic sciences with respect to scientific personnel resources in different academic ranks and areas of specialization. The second concerns historical developments and findings from the statistical analyses. Comparisons of scientific personnel growth are given last.

THE PRESENT SITUATION

Academic Rank and Institutions

The data compiled in this study reveal that the proportions of scientific personnel at different academic ranks do not constitute

a normal personnel pyramid with assistants at the base and emeritus professors near the top. Turkey's scientific personnel distribution at academic institutions does match this norm, since the number of assistants with doctorate degrees roughly equal the number of professors, while the number of associate professors (docents) is the smallest of the three.

This distorted personnel distribution in academic levels is found in different institutions and in various areas of the basic sciences. The situation in two recently established universities, Hacettepe and Middle East Technical University (METU), is not as distorted as in the rest, but these are exceptions; the other departments and faculties of basic sciences in technical universities and schools of medicine all conspicuously depart from the expected norm.

The vertical personnel flow from lower to highest academic rank meets a bottleneck at the level of assistants with an average 40 per cent loss in the number of assistants with doctorate degrees over those without. The rate of loss varies with the areas of basic sciences, highest in mathematics, then physics, chemistry and the lowest in biological sciences. Presently the number and percentage of basic scientists at different academic levels are as folows :

	Assistants								
	Wo. Dr.	With Dr.	Inst.	Asst. Prof.	Asso. Prof.	Prof.	Non-Acad.	Foreign Total	TOTAL
Number	252	109	52	18	101	149	94	7	782
Percent.	33.6	13.8	6.7	2.2	12.8	19	11	1	100
Only Dr.	—	20	10	3.4	19.8	27	18	1.8	100

As far as the shares of institutions are concerned, IUFF has forty seven per cent, AUFF seventeen per cent, ITU twelve per cent, METU and EUFF ten per cent each, and EAUFF, Hacettepe and KTU have four per cent of all doctors of basic soiences that Turkey had in 1966. Scientists with M. D. background were not included in this calculation.

Areas of Basic Sciences

According to the data, the absolute numbers of scientists in different disciplines vary from one discipline to another. When the numbers of scientists serving in the training institutions are

compared to those who prefer to opt out of an academic career the following are observed:

	Math.	Phys.	Astro.	Chem.	Bio. Sc.
Dr. Sc. at Inst.	90	70	11	87	77
Opting out (number)	11	5	4	34	20
Feedback (Per cent)	90	92	36	40	26

When we exclude the findings of astronomy where the figures are too small to be meaningfull and where almost all those who preferred opting out work in the Observatory of Istanbul which functions as an extension of the chair of astronomy at IUFF, it is quite clear from the data that in chemistry and in biological sciences, to a lesser degree, that some appreciable amount of opting out occurred. In the remaining institutions examined, a very high per cent of feedback was observed in all other disciplines investigated.

An average of thirteen per cent of the present basic scientists were originally applied scientists, mostly engineers and physicians. The switch from applied to basic sciences occurred more frequently in biological sciences, chemistry and mathematics.

Nationality and Sex

The data also provided information concerning the sex and nationality of the scientists in Turkey. Today only a small per cent of all scientists in basic disciplines in Turkey are of foreign nationality. Foreign scientists who served in Turkey for durations shorter than a year were not included in this calculation. Presently, the majority of foreign scientists are at Middle East Technical Universty (METU).

According to data, one out of every three basic scientists (thirty seven per cent) is female. Sex affects the proportion of scientists promoted to higher academic ranks. A higher ratio of male assistants without doctorates earned their doctorate degrees. The rate of promotion is higher for male scientists. These general trends concerning the sex of scientists hold true in different institutions and areas of basic sciences investigated.

HISTORICAL DEVELOPMENT

Before elaborating the findings resulted from the analyses of the data covering the last 33 years of development of Turkish science in the Turkish Republic, a brief exposition of the nature of science in the Ottoman era appears to be a necessary step for a a deeper understanding of to-day's science.

Science in the Ottoman Era

Science at the early stages of the Ottoman was under a strong impact of, if not at all imported from, the science of Islam and Semerkhand.[37, 38] In fact the 14th and early 15th centuries Ottoman scholars (e. g. Kadızade-i- Rumi) were mostly educated in the centers of excellence of science of the time such as HORASAN and SEMERKHAND located in Central Asia. This trend, that is importation of science from foreign sources, continued till present time with a lesser degree. There were some considerable gains in the opposite direction during the last two decades, yet the sources of importation of science had switched from east or Islam to West or to Greek and Europe. During the last two decades of our scientific development however, having some, even if a few yet, research front scientists of our own, Turkey has started taking steps necessary for acceptable membership in «the world society of science». It is these last crucial steps that made Turkey not a borrower nation of science of all times but also a giver one, if little to give yet.*

The first significant incidence which brought scholars of the early Ottoman face to face with the original body of scientific knowledge, that is with the original sources of science, took place when Istanbul (then Constantinople) was captured from the Byzantines (1453). This happened because in the collection of Mehmet II (1451-1481) there were 587 inscripts written in other than Islamic languages. Among them 75 were in the fields of mathematics and physical sciences including such important works as:

1. Claudius Ptolomaios' Almageste, Geography, maps
2. Geminos' Astronomy, 3. Appolonios' Konika (Conics),
4. Serenos' Mathematics 5. Euclid's Geometry

(*) As the data of this study indicate there appears a relative but considerable increase in the number of scientific papers of Turkish scientists in the leading journals of science of the world.

and many others on minerals and animals, theogony, principles of Archimedes, plane geometry, solid geometry, lives of philosophers.[37] Only one, Ptolomaios' Geography was translated into Ottoman Arabic for some pragmatic reasons perhaps. The rest of the original sources remained more or less untouched. The famous scholars of Mehmet II period like Ali Kuşçu, Ak Şemseddin, Ali Bin Elhaç İlyas generally were involved in the interpretation of knowledge of Semerkand astronomy which undoubtedly was highly developed at that time, and translation of some works of medicine from mostly Islamic Sources and rarely from other sources (*Paracelsus' Medicine*) into Ottoman Arabic.[37]

It may be thus concluded that from its founding (1299) to the reign of Mehmet II science did not occupy any privileged position in the socio-economic life of the Ottomans. As far as the development of science itself is concerned, the contributions of the Ottoman scholars to the advancement of science was very limited, if not none at all. The primary function of the scholars of the time was teaching which essentially was based on the interpretations of the essays mostly Arabic and Persian origins. As to the disciplines of science, mathematics and astronomy occupied top positions in the scientific endeavor, medicine, geography and natural studies followed them but not as frequently. Only mathematics and astronomy seem to have a scientific flavor similar to those of today. Medicine, more or less as it is today, was far from being a science, yet had application, even if limited, in ten hospitals of that time.

The contented life of the Ottoman without having any appreciable science continued long centuries until military defeats shook the trust of the political power of the Ottoman in their own military strength and led them to question the possible causes of supremacy of the Western forces, then western societies. As Lewis puts it, «while Europe swept forward in science and technology, the Ottomans were content to remain in their agriculture, and their transport, *and their science* at a level of their medieval ancestors.»[37]

The first signs of discontentment came right after the Treaty of Passarovitz, 1718. The idea that something should be done to prevent the military defeats of the Ottoman has turned the faces of the rulers to the west which in a way created a second opportunity for the Ottoman science—possession of the collection of original science sources at Mehmet II being the first—which led to the es-

[37] Italics are mine.

tablishment of the first printing house in the Ottoman by İbrahim Müteferrika (1670 - 1754) a Hungarian renegade. With him and with his newly established printing house, the Ottoman scholars would have another access to the origins of the basic sciences, because he «was the man to introduce the idea of change and progress and modern scientific thinking to Turkey» [51]. In 1733 he printed CIHANNUMA, KATİP ÇELEBİ's geography whose introduction he included the ideas of Copernicus and Tycho Brache and said that these ideas weren't yet accepted by the Muslim Ulema (Scholars).[37] Müteferrika also discussed, for the first time in Turkey, Descartes' theory of vortices, Galileo's rejection of Aristotelian physics, magnetism and the compass; and printed a small but important essay on magnetism titled *Fuzuyat-i Miknatisiyc* which may be based on William Whiston's *The longitude and Latitude Found by Inclinatory or Dipping Needle* (London, 1719-21). İbrahim thus became one of the early transmitters of modern science to the Ottoman.

Yet, the years that followed İbrahim were spent not for the creation of a suitable milieu for science rather still importing the European technologies to overcome military inferiorities of the Ottoman. Thus this led to achieving some psuedo changes such as opening of Hendesehane [51], school of Military engineering, in the technological and political structure of the Ottoman without introducing fundamental changes in basic sciences, basic science education at higher level, or in the mentality of the Turkish peasentary.[37] Therefore the reformation movements occurring during the Tulip Era led to the creation of such western type educational institutions as Naval Academy, School of Engineering (Mühendishane). These were institutions of technology and military training with little or no emphasis on basic sciences. However, at least in this period for introducing the modern mathematics to Turkey, some steps were taken,[46] and a determined effort to translate some European books of science continued. This resulted Esat Efendi's translation of Aristotle's Physics from Greek into Arabic, also the translation of other sources in medicine and general knowledge like encyclopedia.[37]

The spirit of scientific activities that Müteferrika had kindled did not go far after his death which followed the cease of printing activities of his printing house in 1783. The channels which were used to disseminate the printed modern scientific knowledge among the learned groups of the Ottoman were clogged for a period, at a

time when this knowledge was greatly needed for supporting the Reform efforts. Although many educational reforms were achieved in the periods of Tazminat and Constitutional Abolutism, their impact on the establishment of science and scientific endeavour was rather secondary. These reforms were nothing but surface achievements such as translating textbooks and encyclopedias, bringing foreign scholars specialized in such sciences as engineering and medicine to instruct in their mother languages — mostly in French — a group of trainee, the majority of which came from the Ottoman minorities. While the Ottomans were busy with such activities, science in Europe under the leadership of such pioneering scientists as Lagrange (France), Euler (Switzerland) Newton (England, a bit earlier) James Bradley (England) Laplace (France), Huygens (Germany), etc. progressed rather rapidly and the newly established scientific societies served for such rapidity in disseminating the scientific ideas and opening up new paths of communications in science.

It is interesting to note that in the early Tanzimat (Reformation) period both the Ottomans and Japan were intensively concerned with translation of Western sources of science into their mother languages. While the endevour was marked as being the first stage of Scientific Revolution of Japan (1774 - 1853) and was so utilized in reality [9] the similar activities in the Ottoman have not led to the beginning of scientific revolution in Turkey. The causes of such an appearence are to comlex and deserve further investigations which are beyond the scope of the present study.

In conclusion it may be said that science in the Ottoman was sporadic and isolated. It was the application of science rather than science itself which the Ottomans sought to import and to utilize. The attemps to adopt western science and technologies, at least those made in an orderly manner, were made for the purpose of strenghtening the Ottoman army and re-establishing its supremacy over the western forces. The traces of science which came through individual efforts did not evoke changes in the old institution of education, the medrese, in the Ottoman. The impact of the individual efforts which caused the importation of a new body of scientific and technical knowledge has led to the establishment of the bifurcation of education between the elite and the masses of ordinary citizen. At no period of the Ottoman history the scholars in general were the creators of science, and therefore Ottoman society was a barrower society of science. Japan, on the other hand, became

capable of contributing to the advancement of science, despite the fact that it had begun its scientific endeavour more or less at the same period as the Ottomans.

As far as the educational institutions of science are concerned, the teaching of basic sciences at higher level began as early as 1734 with the establishment of school of engineering (Hendesehane) in Istanbul. The foundation of a school of basic sciences was laid in 1862. Distruction of fires and ignorance, however, deemed this activity and a fresh attempt had to be made in 1869 by opening a new institution called Darulfununu Şahane (Institution of Higher Learning). This institution had a section of mathematics and natural sciences. The yearly enrollment in this section was in the vicinity of twenty five students. In this institution, mathematics was instructed by Margosyan Efendi and Salih Zeki Bey, whereas physics was taught by Dervış Paşa, chemistry by Vasil Naum Efendi, Zoology by Remzi bey, botony by Esat Şerafettin Bey, Earth Sciences by Ahmet Müştak Bey. The Darulfunun (Today's University) was reorganized in 1912 and the name of «Faculty of Science» was then adopted. After several closing and reopenings in 1915, and 1918 science education in higher level was once more reorganized in 1926 when teaching staff of the Faculty of Science was reinforced by visiting professors from France who were specialized in mathematics, physics, chemistry and biological sciences. The faculty was then again called «Medresa».

I may now turn to expose the nature of science in the Turkish Republic where infrastructure, both legal and partly mental, for the flourishing of science has been more apt since secularism which is a precondition for scientific endeavour was at least somewhat established in this era by Atatürk's reforms.

Science in The Turkish Republic

As far as higher learning in science is concerned, there appears various trial and retrial efforts in the early stage of the Turkish Republic, that is between 1920 - 1933 when the foundation of a new society was laid. For instance, while Darülfunun was under the control of the Ministry of Education prior to 1924, in April 24, 1924 the control was abolished and Darülfunun was given authonomy. Yet 1933 University Reform resulted in placing the control of the university again under the auspeices of the Ministry of Education. This new regime of the university continued till 1946 when univer-

sity reassumed authonomy. A first planned effort to reorganize science through the institutions of science was know as the University Reform Act of 1933. It was thought that a fresh start would be necessary for a rapid establishment of up-to-date minded nucleus of Turkish scientists and univerity staff. The plan adapted for the realization of such a reform was somewhat similar to the the plan of operation that Japan applied in their Meiji Restoration when «Japanese were being taught modern science (and techonology) under the tutelage of foreign instructors» while a group of promising young Japanese were sent abroad to be specialized in various disciplines of science.[59]

Analyis of our data reveal that a somewhat similar plan of operation for the first Reformation Period of Turkish Republic was put into effect in 1933. The first staff of the Faculty of Science, University of Istanbul following the inauguration of the act was composed of following Turkish and foreign members:

Foreign staff: Von Mises (Mathematics), Prager (Mathematics), Freundlich-(Astronomy), M. Fouché (General Physics), Dember (Experimental Physics), G. Valenski (Physical Chemistry, Merzog (Industrial Chemistry), A. Naville (Zoology), Brauner (General Botany), Heilbron (Pharmacobotany and genetics), Duscio (Electromagnetics), Von Hippel (Electricity).

Great majority of foreign staff were professors from German universities.

Turkish Staff : The only Turkish staff member at professor level was Kerim Erim (Math., deceased), the rest were assistant professors. Cahit Arf (Math. Ord. Prof., retired now M.E.T.U.), Ratip Berker (Retired Ord. Prof. of Math, now Liege, Fr.) Ferruh Şemin (Geometry, now Prof.) Celal Saraç (Physics, Prof. at EGE univ.) Nusret Kürkçüoğlu (Experimental Physics, Prof., now İstanbul Technical Univ.) Ali Rıza Berkem (Physical chemistry, now prof.) Tarık Artıl (General Chemistry at academy of fine arts, Istanbul), Tahsin Rüştü Beyer (Gen. Chem. deceased). Turhan Şeşbeş (Gen. Chem. retired), Saffet Rıza Alpar and Haldun Nüzhet Terem (Industrial Chem., profs.) Fahire Battalgil, Fazıla Şevket Giz, and Suat Nigar (Zoology, Profs.) Şevket Aziz Kansu (Antropology, now prof. at Faculty of Letters, Ankara Univ.), Kadri Uzman (Elect-

romechanics, deceased), Fahrettin Tanman (non academician).

Two professors Ali Yar (math.) and Hamit Nafız Pamir (chem) and one asst. prof. Fahir Yeniçay (Physics) were transfered from the earlier (prior 1933) university establishment.

A very great majority of Turkish staff members were trained abroad, most of them in France. It is interesting to note that in the faculty of science of University of Istanbul which happened to be the first and the only higher institution of science the ratio of foreign staff to Turkish was 12/3 at professorial level, and 12/21 in overall personnel at various academic levels, in 1933. Whereas in 1966 only two out of 188 staff members (including assistants) were foreign professors. Below is given other findings resulted from the analyses made on the data collected by this study.

Findings concerning the chronological development of the basic sciences are given first for personnel development in the four major groups and some sub-groups, then for research and publication and duration of education and length of service of scientists.

Personnel Development at Doctorate Level (Group A)

Findings concerning the development at (Group A) level is given in table 1 and in figs. 1 and 2. The data and frequency curve for the total scientific personnel indicate that:

1. The rate of growth was negatively affected by World War II.
2. A rather sharp increase was observed in the rate of growth right after the war.
3. There were two distinct periods of rather steady increase in the rate of growth of the scientists. One of the two periods was before the war (1933-39) and the other after the war especially between 1958-66. The average increase in the pre-war period was 8 scientists per year whereas it was 17 per year after the war. A rather sharp jump which occured right after the war may be attributed to «after war counter balance» which is observed in other countries[56] and/or to some socio-political and economical forces which directly concerned the universities.

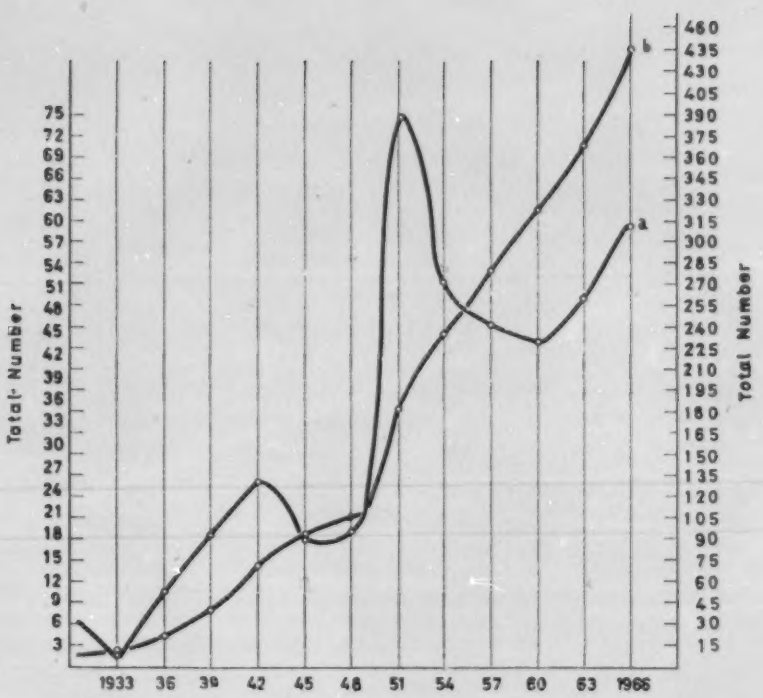


FIG. 1. Curve (a) shows rate of growth of scientific personnel (Group A). (Source A.K.Ö.) Curve (b) shows total number of scientific personnel (Group A).

Among the latter, the autonomy given the university (1946), opening of a new faculty of science in Ankara (AUFF), the larger number of Kadros* provided to the universities by Government funds, the beginning of regeneration activities by the Turkish senior scientists may be mentioned. Yet, to draw more reliable conclusions in this respect requires further analyses of the socio-political forces which is beyond the immediate scope of this study.

4. In different areas of the sciences the rate of growth of scientific manpower (sub-groups of **Group A**) vary despite the fact that each of the four basic sciences (mathematics, physics, che-

(*) «Kadro» denotes the quota allocated to an institution by the government indicating the number of personnel to be employed at certain wage levels at a certain year.

mistry and biological sciences) follows a pattern of growth similar to that of **Group A** (Fig 2a; table 1). Personnel development in astronomy and interdisciplinary areas shows no appreciable rate of growth and there are sharp irregularities. The rates of growth in chemistry and the biological sciences are appreciably higher than those of mathematics and physics.

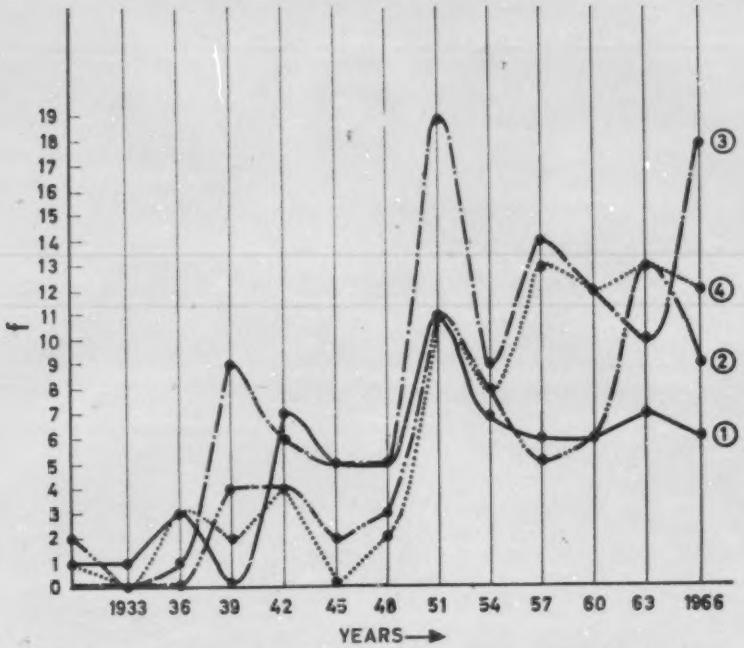


FIG. 2a. Rate of growth in various basic science disciplines (Group A). Throughout, f = frequency increase within 3 year period. Mathematics (1); physics (2); chemistry (3); biological sciences (4). (Source A.K.Ö.)

5. The same growth pattern in the cumulative number of scientists in mathematics, physics, chemistry and biological sciences is shown in fig. 2b.

There are close similarities between manpower growth of individual science areas and that of scientists in **Group A.** As a matter of fact when the variation in the percentage the ratio of scientists engaged in different discipline of science to the total growth is traced over the period of 33 years, it appears no signifi-

Table 1. Scientific manpower development at doctorate (Group A) level in 33 years. Frequency distribution of different disciplines

Years	Total f	Total cumf	Areas of Specialization: Mathematics f	Mathematics cumf	Physics f	Physics cumf	Astronomy f	Astronomy cumf	Chemistry f	Chemistry cumf	Bio. Sc. f	Bio. Sc. cumf	Int. Ds. f	Int. Ds. cumf	Earth Sc. f	Earth Sc. cumf	Medicine f	Medicine cumf	Blank
1967	12	444	4	65		65		11	3	107	2	97	1	27		39	2	30	
1964-66	63	432	5	61	9	65	2	11	18	104	12	95	3	26	10	39	4	28	
1961-63	55	369	8	56	13	56	1	9	10	86	13	83	5	23	2	29	3	24	
1958-60	44	314	7	48	6	43	—	8	12	76	12	70	1	18	1	27	5	21	
1955-57	47	270	7	41	5	37	—	8	14	64	13	58	2	17	4	26	2	16	
1952-54	51	223	8	34	9	32	3	8	9	50	9	45	7	15	3	22	3	14	
1949-51	75	172	11	26	11	23	4	5	9	41	10	36	4	8	8	19	7	11	1
1946-48	19	97	3	15	2	12	—	1	5	22	5	26	1	4	2	11	—	4	1
1943-45	17	78	2	12	—	10	—	1	5	17	5	21	—	3	3	9	1	4	1
1940-42	26	61	4	10	4	10	—	1	7	12	6	16	2	3	3	6	—	3	
1937-39	18	35	2	6	4	6	1	1	—	5	9	10	—	1	1	3	1	3	
1934-36	10	17	3	4	—	2			3	5	1	1	1	1	1	2	1	2	
-33	1	7	0	1	—	2			1	2					—	1	—	1	
Before 1933	6	6	1	1	2	2			1	1					1	1	1	1	
Blank		86		23		13				14		2							

Sample	: 530	88	78	121	99
%p/q	: 86/444	23/65	13/65	14/107	2/97
(P)Table Value	: 0.52; 0.78	0.52; 0.78	0.52; 0.78	0.52; 0.78	0.52; 0.78
(P)Observed	: 0.01	0.16	0.04	0.03	0.01
Significance	: ++*	++	++	++	++

* Throughout the tables the sign ++ denotes that sample size is significant at $P \leq 0.01$ level.

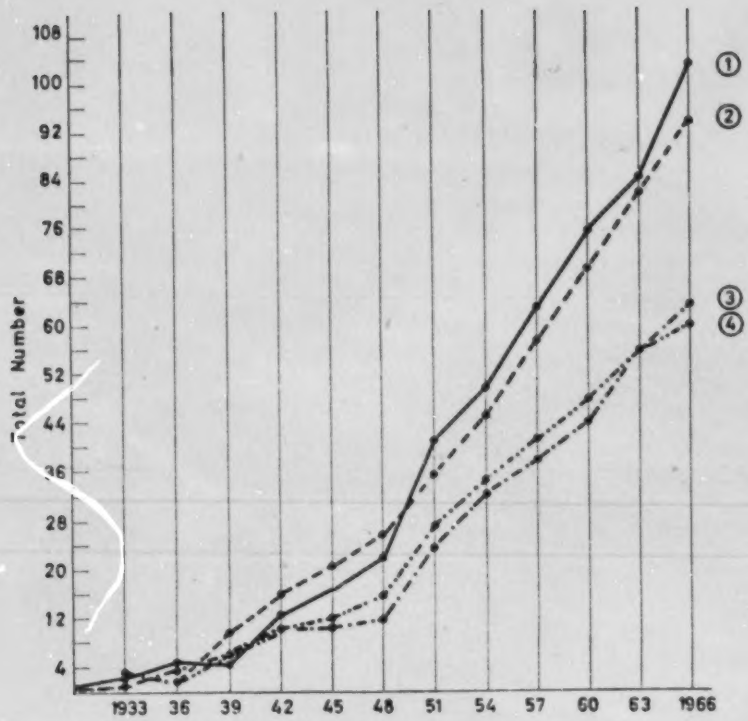


Fig. 2b. Total number of scientific personnel in various basic sciences (Group A level). Chemistry (1); biology (2); physics (3); mathematics (4) (Source A.K.Ö.).

Growth of Manpower in Various Sub-disciplines of science between 1933-66 in Turkey

		Number of Scientists in							
Years	Total	Math	Phys.	Astro.	Chem.	Bio.Sc.	Int.Ds.	Earth.Sc.	M.D.Sc
1952-67	272	39	42	6	66	61	19	20	19
1949-51	75	11	11	4	19	10	4	8	7
1933-48	91	14	10	0	21	26	4	10	3
Before	6								
		Changes in Percentage of Sub-disciplines to the Total Growth							
1952-67	100	14	15	2	24	23	7	7	7
1949-51	100	15	15	5	25	13	5	11	9
1933-48	100	15	11	0	23	29	4	11	3

cant change in the percentages. This simply means that science grows uniformly, that is as one part of it grows other parts also grow accordingly. This finding of mine fits well within the generalization of D. Price who concludes, as a result of his thorough analyses of the available international data, that science grows as if it has a predetermined balance among its sub-disciplines.[56] The figures based on Turkish case which indicate this peculiarity of science are given below.

6. The Faculty of Sciences of the University of Istanbul (IUFF) ranks first in contributing to the numerical growth rate of Turkish scientists in Group A, and the Faculty of Sciences of Ankara University (AUFF) is a good second (table 2, fig. 3a).

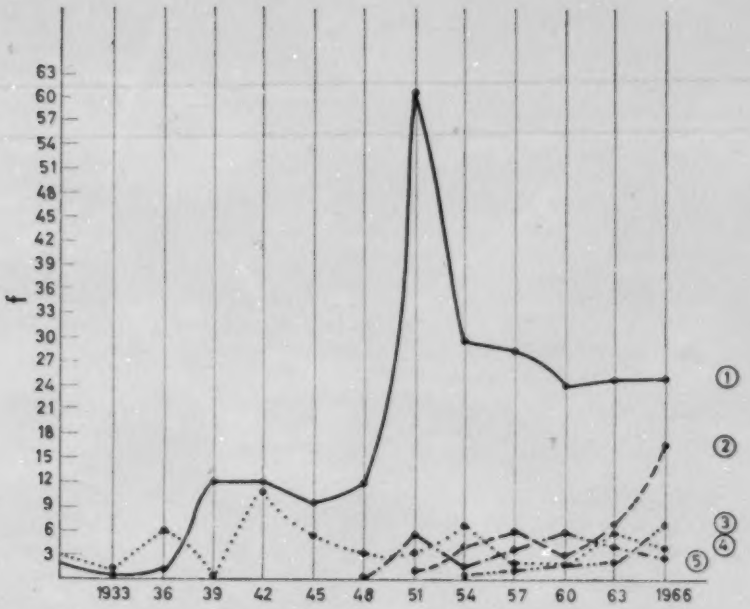


Fig. 3a. Growth rate at Group A level in various institutions. IUFF (1); AUUF (2); ITU (3); foreign countries (4); IU (others) (5). (Source A.K.Ö.).

(a) The contribution of foreign scientists and Turkish scientists trained abroad reached a maximum in 1942 and lessened thereafter. The impact of foreign scientists who served in Turkish Uni-

Table 2. Scientific development at doctorate (Group A) level in 33 years. Frequency distributions of different institutions

Years	Total f	Total cumf	IUFF f	IUFF cumf	IU (other) f	IU (other) cumf	ITU f	ITU cumf	AUFF f	AUFF cumf	AU (other) f	AU (other) cumf	Foreign Count. f	Foreign Count. cumf	EUFF f	EUFF cumf	EU (other) f	EU (other) cumf	Nation. (other) f	Nation. (other) cumf	Blank
1967	12	444	1	246	1	36		12	6	44	2	12		50		1			1	25	1
1964-66	63	432	26	245	3	35	7	12	17	38	3	10	4	50	1	1			2	24	0
1961-63	55	369	26	219	4	32	2	5	7	21	1	7	6	46					2	22	7
1958-60	44	314	25	193	6	28	2	3	3	14	2	6	2	40					2	20	2
1965-57	47	270	29	168	4	22	1	1	6	11	1	4	2	38					4	18	0
1952-54	51	223	30	139	2	18			4	5	2	3	7	36					6	14	0
1949-51	75	172	61	109	5	16			1	1	1	1	3	29					3	8	1
1946-48	19	97	12	48	0	11							3	26					2	5	2
1943-45	17	78	10	36	1	11							5	23					1	3	0
1940-42	26	61	12	26	1	10							11	18					1	2	1
1937-39	18	35	12	14	6	9							0	7					0	1	0
1934-36	10	17	1	2	1	3							6	7					1	1	1
-33	1	7	0	1	0	2							1	1							
Before 1933	6	6	1	1	2	2															3
Blank		86	38	38	0				4	4		0	26	26					7	7	17
Sample :	530		284						48				76								
% p/q :	86/444		38/246						4/44				26/50								
(P) Table Value :	0.52; 0.78		0.52; 0.78						0.52; 0.78				0.52; 0.78								
(P) Observed Value :	0.001		0.07						0.04				0.06								
Significance level .	++		++						++				++								

25

versities will be reconsidered later in relation to the training of young Turkish scientists.

(b) The pattern of the rate of personnel development of IUFF has dominated Turkish personnel development in the basic sciences.

(c) Approximately sixteen to twenty years elapsed before IUFF began regenerating the first home grown doctors of basic sciences. In Universities which had no faculties of science but had chairs of science this duration was appreciably longer. The variability of time in the frequency of regeneration of home grown doctors of basic sciences was much larger in these institutions than those in the faculties of basic sciences.

7. To speak meaningfully of the «doubling period» and «ten fold increase» with respect to manpower development in science requires that the development is exponential. Since Turkey has not as yet reached such an exponential development the term doubling period here expresses the relative rates of change observed in different disciplines of science and in the contributions of institutions merely by inspecting the data concerning the growth occured during the past 33 years.

As figs. 2a and 2b, and data in table 1 (p. 22) reveal the period for doubling personnel varies from one area of science to another. Doubling was relatively faster in chemistry and biological sciences and relatively slower in physics. No appreciable change was observed in the personnel growth of astronomy.

8. The rate of growth of scientific personnel varied also with the institutions of basic sciences. The growth was faster in IUFF than both AUFF and EUFF. The rate of growth was relatively much less in ITU where chair organization rather than faculty or department system is common. (See data in Table 4 and figs. 3a and 3b).

Personnel Development at Associate Professorial Level (Group C)

The finding on this level are as follows (fig. 4; table 3):

1. While the growth rate at doctorate level (Group A total; reaches a maximum in 1951, for Group B it is reached in 1966.

2. The fluctuations of the growth rate of Group B are not so severe as those of Group A.

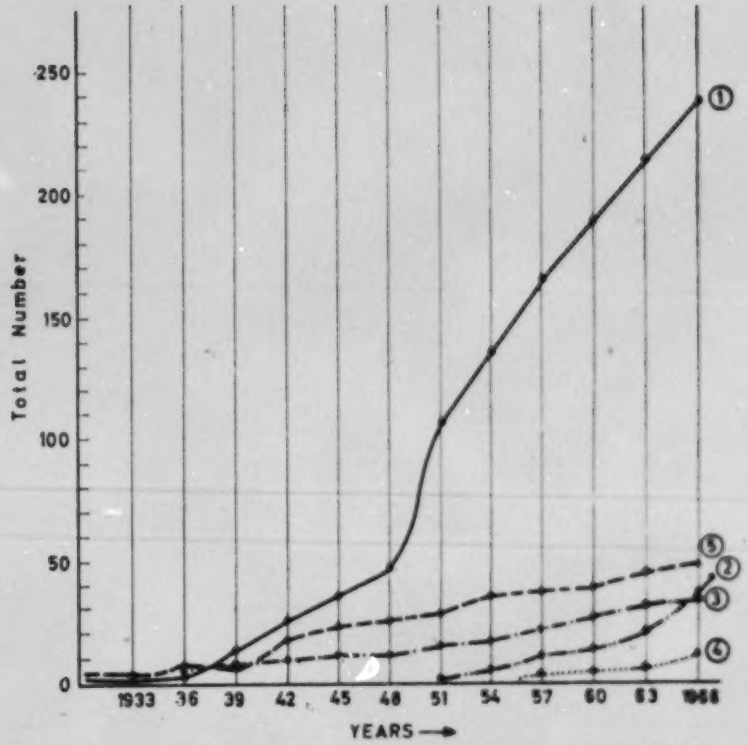


Fig. 3b. Total number of scientific personnel (Group A). IUFF (1); AUFF (2); IUTF & IUEF (3); ITU (4); foreign countries (5). (Source A.K.Ö.)

3. As to the growth rates in different institutions, IUFF has its maximum during the period 1954 - 67, while AUFF has irregularities and thus no appreciable pattern of development. It is too early to analyse the trend of personnel development at Group C level in the recently established universities. Personnel at this level in some of the old technical universities and schools of medicine develops haphazardly as compared to the growth of professors.

4. In the 1957-60 period, personnel growth rate increased in the biological sciences and was steady in chemistry, while the rate decreased in other areas of the basic sciences.

5. If the lower limit for the definition of scientists is established at Group C level, the doubling period of scientific personnel

Table 3. Scientific manpower development at (Group C) associate professor level in 33 years. Frequency distributions for different disciplines

Years	Total f	Total cumf	Areas of Specialization: Mathematics f	Mathematics cumf	Physics f	Physics cumf	Astronomy f	Astronomy cumf	Chemistry f	Chemistry cumf	Bio. Sc. f	Bio. Sc. cumf	Int. Ds. f	Int. Ds. cumf	Earth Sc. f	Earth Sc. cumf	Blank
1967	4	212	1	25	1	39	—	6	1	41	—	59	1	23	—	8	
1964-66	33	208	3	24	5	38	1	6	5	40	13	59	2	22	2	8	2
1961-63	24	175	4	21	4	33	—	5	5	35	8	46	3	20	—	6	
1958-60	24	151	2	17	3	29	1	5	6	30	8	38	3	17	—	6	1
1955-57	27	127	4	15	5	26	1	4	5	24	6	30	4	14	2	6	
1952-54	25	100	2	13	4	21	2	3	4	19	6	24	3	10	2	4	2
1949-51	13	75	2	11	3	17	—	1	2	15	5	18	—	7	—	2	
1946-48	14	62	2	9	2	13		1	1	13	7	13	1	7	—	2	1
1943-45	14	48	1	7	5	11	—	1	4	12	—	6	3	6	1	2	
1940-42	11	34	2	6	2	6	—	1	2	6	3	6	1	3	1	1	
1937-39	9	23	1	4	—	4	—	1	6	6	1	3	2	2	—		1
1934-36	5	14	1	3	3	4	1	1	—	2	—	2	—		—		
-33	6	9	2	2	—	1	—		2	2	1	2	—				1
Before 1933	3	3			1	1	—				1	1	—				1
Blank	28		9		3		1		1		6						
Sample :	240		34		42				42		65						
Σ p/q :	28/212		9/25		3/39				1/41		6/59						
(P) Table Value :	0.52; 0.78		0.52; 0.78		0.52; 0.78				0.52; 0.78		0.52; 0.78						
(P) Observed Value :	0.05		0.08		0.04				0.02		0.03						
L. of Significance :	++		++		++				++		++						

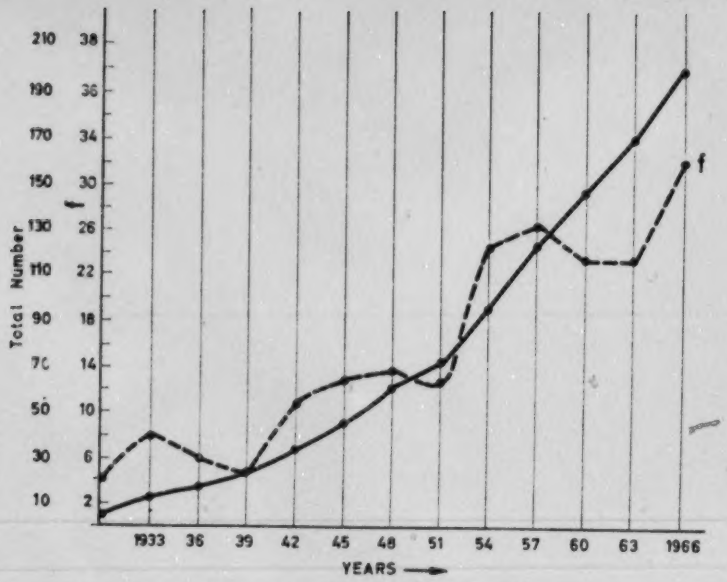


Fig. 4. Development of scientific personnel (Group C). (Source A.K.Ö.)

becomes approximately: 11 years for the total group with a maximum in the 1937-48 period; a maximum of 14 and minimum of 8 years in mathematics; a maximum of 11 and minimum of 8 years in physics; a maximum of 12 and minimum of 7 in chemistry; and a maximum of 10 years and minimum of 3 years in the biological sciences.

6. The doubling period increases from 1933 to 1966.

Personnel Development at Professorial Level (Group D)

The findings concerning personnel development at this level are as follows (fig. 5, table 4):

1. The rate of growth in this group has been the most consistent of all the four groups, except in the 1943-45 period.

2. The percentage of articulation from Group A level to Group D is 28 per cent, and there is 60 per cent articulation from Group C to D.

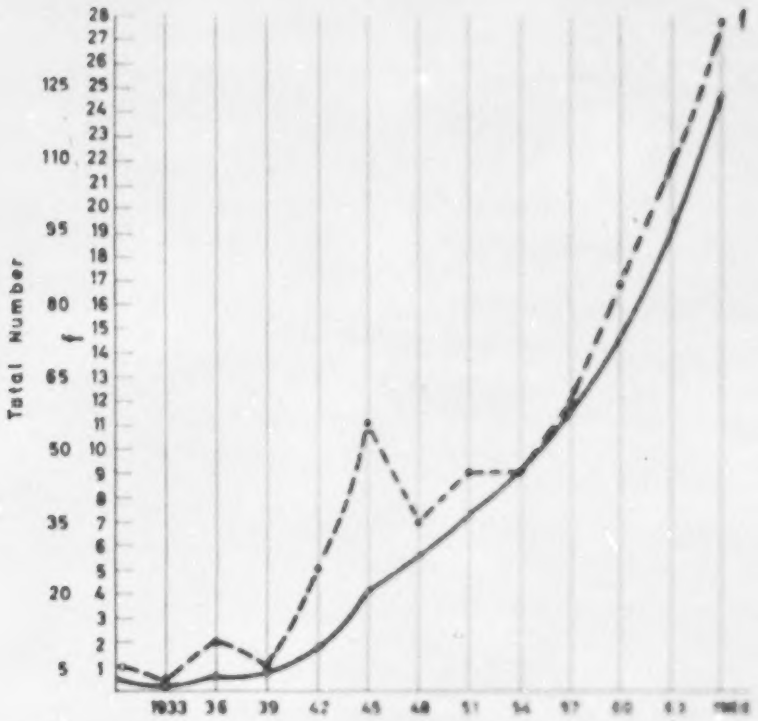


Fig. 5. Frequency and total number of scientific personnel development (Group D). (Source A.K.Ü.)

3. With réspect to contributions to personnel development at this level IUFF ranks first and AUFF second. The contribution of ITU has been limited and irregular. No appreciable pattern could be identified for the contributions of EUFF and other recently established universities.

4. Findings concerning personnel in various fields of the basic sciences are as follows: (a) Number of scientists in the four basic scientific areas (mathematics, physics, chemistry, biology) were almost equal in 1933-57. (b) Between 1957 and 1964 the number of scientists in physics exceeded those in the other disciplines. (c) Biological sciences had the greatest growth rate between 1964-67.

Table 4. Manpower development at (Group D) professorial level in 15 years. Frequency distributions for various disciplines in basic sciences

Years	Total f	Total cumf	Areas of Specialization: Mathematics f	Mathematics cumf	Physics f	Physics cumf	Astronomy f	Astronomy cumf	Chemistry f	Chemistry cumf	Bio Sc. f	Bio Sc. cumf	Int. Sc. f	Int. Sc. cumf	Earth Sc. f	Earth Sc. cumf	Blank
1967	4	128		16	2	24		3		20	2	32		18	3	7	1
1964-66	28	124	2	16	2	22		3	1	20	10	30	7	18			1
1961-63	22	96	4	14	3	20	1	3	4	17	6	20	3	11	1	4	2
1958-60	17	74		10	5	17		2	3	13	4	14	2	8	1	3	1
1955-57	12	57	1	10	3	12		2	3	10	2	10	1	6	1	2	
1952-54	9	45	1	8	2	9		2	2	7	2	8	1	5	1	1	
1949-51	9	36	1	8	1	7		2	2	5	2	6	2	4			
1946-48	7	27	2	7		6	2	2	1	3	2	4		2			
1943-45	11	20	4	5	3	6			1	2	2	2	1	2			
1940-42	5	9	1	1	1	3			1	1			1	1			1
1937-39	1	4			1	2											1
1934-36	2	3			1	1											
-33	0	1															
Before 1933	1	1									1						
Blank		20	6		4				2		2				2		
Sample:	148		22		28				22		36						
% p/q:	20/128		6/16		4/24				2/20		2/32						
(P) Table Value:	0.52; 0.78		0.52; 0.78		0.52; 0.78				0.52; 0.78		0.52; 0.78						
(P) Observed Value:	0.03		0.014		0.09												
L. of Signifi-cance	++		++		++				++		++						

5. The time required for doubling the personnel at this level (Group D) was in most cases less than the time required at Group A and C levels.

6. Turkish basic scientists have reached full professorships 8 to 28 years after receiving the doctorate. The break down of the time spent in this period with respect to institutions are as follows :

Institution	Average Time (Years)	Time Limits (Min.-Max. Years)	Median
IUFF	18	8 - 28	17
ITU	17.5	12 - 27	15
AUFF	13.7	18 - 28	13
EUFF	13.7	10 - 20	13
METU	12	9 - 16	11

7. It was observed that the time elapsed between doctorate and full professorships has not varied with such areas of specialization as chemistry, physics, and interdisciplines. In biological sciences, however, half of the scientists have reached full professorships 19 to 28 years after receiving the doctorate.

FINDINGS ON RESEARCH AND PUBLICATIONS

Publications in the basic sciences during the period of thirty-three years are grouped as : (1) translations, (2) monographs or eclectic pamphlets, (3) texbooks, and (4) research papers. The data collected represents the response of only a portion of the total number of scientists. It is, therefore, important to note that the findings given below are far from providing a sufficient basis for generalization and have a limited value except for research papers where sufficient data were collected.

Translation in Basic Sciences

The minimum and maximum numbers of books translated by a single scientist are one and thirteen. The highest average for translation is at Group D level. The distrubution of books translated by scientists at different levels is as follow (table 5) : (a) two per cent of the assistants with doctorate (Group B), (b) six per cent of the instructors, (c) sixteen per cent of the associate professors (Group C), (d) forty per cent of the professors (Group D) translated books of science varying between one and thirteen.

Monographs Published in the Basic Sciences

Eclectic publications, popularizations and mass-media articles were considered as monographs. The number of monographs published in the period covered by this research exceeds the number of translations. The distribution is as follows (table 6): 8 per cent by assistants with doctorate degree (Group B), 21 per cent by associate professors (Group C), and 27 per cent by professors (Group D). The number of publications per publishing professors varied between one and forty.

Table 5. Translations published in basic sciences

(Frequency of translations) f	Academic Levels *								Persons f (total)	Total no. of translations
	1	2	3	4	5	6	7	8		
1	0	1	1	1	8	23	0	0	34	34
2	0	0	0	1	5	13	0	0	19	38
3	0	0	1	0	0	10	1	0	12	36
4	0	1	0	0	0	6	0	0	7	28
5	0	0	0	0	3	2	0	0	5	25
6	0	0	0	0	0	3	0	0	3	18
7	0	0	0	0	0	3	1	0	4	28
8	0	0	0	0	0	2	0	0	2	16
10	0	0	1	0	1	0	0	0	2	20
13	0	0	0	0	0	1	0	0	1	13
Total (Positive Resp.)	0	2	3	2	17	63	2	0	89	
Total (Blank or zero resp.)	250	110	49	15	84	83	1	94	693	
G. Total	250	112	52	17	108	146	3	94	782	
Total Number of Translations		5	14	3	43	181	10			256

Source - A.K.O.

* 1 — Assistant
2 — Assistant with doctorate
3 — Instructor
4 — Assistant Professor
5 — Associate Professor
6 — Professor
7 — Ordinary Professor
8 — Non-academic doctorate

Publications as Science Texts

The number of textbooks published by scientists at different academic levels is as follows (table 7):

One out of every 250 assistants published at least one textbook in his field of specialization. The textbook was written for use at university level.

Table 6. Monographs published in basic sciences

Monog. f	Academic Levels * 1	2	3	4	5	6	7	8	Writer f (total)	Total no. of Monog.
1	0	1	0	0	9	14	0	0	24	24
2	0	3	0	1	5	5	0	0	14	28
3	0	0	0	0	1	5	0	0	6	18
4	0	3	0	0	2	0	0	0	5	20
5	0	3	0	0	2	0	0	0	5	25
6	0	0	0	0	1	4	0	0	2	12
7	0	0	0	0	1	1	0	0	3	21
8	0	1	0	0	1	1	0	0	1	8
9	0	0	0	0	0	1	0	0	1	9
10	0	0	0	0	0	1	0	0	3	30
12	0	0	0	0	0	2	1	0	3	36
16	0	0	0	0	1	2	0	0	1	16
28	0	0	0	0	0	1	0	0	1	28
29	0	1	0	0	0	0	0	0	1	29
36	0	0	0	0	0	0	1	0	1	36
40	0	0	0	0	0	1	0	0	1	40
Total (Positive Resp.)	0	9	0	1	21	39	2	0	72	
Total (Blank or zero resp.)	250	103	52	16	80	107	1	94	710	
G. Total	250	112	52	17	101	146	3	94	782	
Total Number of Translations	54	2	0	60	218	46				380

Source - A.K.Ö.

* 1 — Assistant 2 — Assistant with doctorate 3 — Instructor
4 — Assistant Professor 5 — Associate Professor 6 — Professor
7 — Ordinary Professor 8 — Non-academic doctorate

Table 7. Textbooks published in basic sciences

Textbooks f	Academic Levels * 1	2	3	4	5	6	7	8	Writer f (total)	Total no.of Textbooks
1	0	2	1	0	9	19	0	0	31	31
2	0	1	0	0	2	12	1	0	16	32
3	1	0	0	0	0	11	0	0	12	36
4	0	0	0	0	2	7	0	0	9	36
5	0	0	0	0	0	1	0	0	1	5
6	0	0	0	0	0	3	0	0	3	18
7	0	0	0	0	0	2	1	0	3	21
10	0	0	0	0	0	1	0	0	1	10
11	0	0	0	0	0	2	0	0	2	22
Total (Positive Resp.)	1	3	1	0	13	58	2	0	78	
Total (Blank or zero resp.)	249	109	51	17	88	88	1	94	704	
G. Total	250	112	52	17	108	146	3	94	782	
Total Number of Textbooks	3	4	1		21	173	9			211

Source - A.K.Ö.

* 1 — Assistant 2 — Assistant with doctorate 3 — Instructor
4 — Assistant Professor 5 — Associate Professor 6 — Professor
7 — Ordinary Professor 8 — Non-academic doctorate

The maximum number of textbooks written by the same author is eleven in Group D, four in Group C and two in Group B.

Some scientists in all three levels also published textbooks for use at secondary school level.

Publication of Research Papers

Enough data have been collected on research papers to allow statistically significant generalizations on several points investigated. The findings are as follows (table 8): (a) The majority of science papers (approximately sixty per cent) were published in Turkish journals of basic sciences. Visiting foreign professors published cosiderably more than Turks of equal number. (b) Turkish scientists either living abroad or who traveled frequently to foreign countries appeared to be more productive — that is they published relatively more papers — than those who stayed at home. The number of papers published by publishing one scientist varied between one and forty-five. A visiting foreign professor published more than forty five. (c) Scientists at Group D level were the most productive with respect to scientific papers; yet an almost equal percentage (forty-six per cent) of scientists in both Groups C and D published more articles in foreign journals than they did in Turkish scientific journals. (d) The modes of research papers at professorial level (Group D) are four and seven, at associate professorial level (Group C) five papers, at assistant professorial level (Group A) and lower levels one paper. (e) When the number of scientist is plotted as the function of the number of their publications per scientist the resulting curve is negatively oriented. (f) As the frequency distribution given below reveals, the scientific papers published in physics during the period of thirty-there years reached a maximum by 1957 and doubled in six years near the period of maximum publication. IUFF made the greatest contribution between 1951 - 63, METU surpassed it thereafter. Number of scientific papers does not seem to have a curve of an exponential nature. However, more data are needed to make statistically significant generalization on this point.

Unpublished Research

According to the data collected on 265 scientists from different academic levels, with the exception of assistant professors and instructors, the number of unpublished research increases as the aca-

Table 8. Research papers published in basic sciences

Research papers	Academic Levels *								Writer	
f	1	2	3	4	5	6	7	8	f (total)	Total no. of papers
1	11	8	5	0	7	2	0	4	37	37
2	5	7	3	1	4	2	0	1	23	46
3	3	8	2	3	5	7	0	1	29	87
4	0	2	2	0	7	9	0	1	21	84
5	0	4	2	0	11	6	0	0	23	115
6	0	1	1	0	3	6	1	0	12	72
7	0	0	0	0	6	9	0	0	15	105
8	0	1	0	0	4	7	0	0	12	96
9	0	1	0	0	4	5	0	0	10	90
10	0	0	0	2	6	6	0	0	14	140
11	0	1	0	0	4	5	0	0	10	110
12	0	2	0	1	2	1	0	0	6	72
13	0	0	0	0	0	6	0	0	6	78
14	0	0	0	0	0	4	0	0	4	56
15	0	0	0	0	0	1	1	0	2	30
16	0	0	0	0	1	2	0	0	3	48
17	0	0	0	0	0	3	0	0	3	51
18	0	0	0	0	0	2	0	0	2	36
19	1	0	0	0	1	1	0	0	3	57
20	0	0	0	0	0	4	0	0	4	80
21	0	0	0	0	0	1	0	0	1	21
22	0	0	0	0	0	1	0	0	1	22
23	0	0	0	0	0	1	0	0	1	23
25	0	0	0	0	0	1	0	0	1	25
26	0	0	0	0	0	1	0	0	1	26
27	0	0	1	0	0	0	0	0	1	27
30	0	0	0	0	0	1	0	0	1	30
31	0	0	0	0	1	2	0	0	3	93
33	0	0	0	0	0	1	0	0	1	33
35	0	0	0	0	0	1	0	0	1	35
36	0	0	0	0	0	1	0	0	1	36
40	0	0	0	0	0	1	0	0	1	40
45	0	0	0	0	0	5	0	0	5	225
Total (Positive Resp.)	20	35	16	7	66	105	2	7	258	
Total (Blank or zero resp.)	230	77	36	10	35	41	1	86	523	
G. Total	250	112	52	17	101	146	3	93	781	
Total Number	49	132	68	43	435	1365	21	13		2,126

Source - A.K.Ö.

* 1 — Assistant
2 — Assistant with doctorate
3 — Instructor
4 — Assistant Professor
5 — Associate Professor
6 — Professor
7 — Ordinary Professor
8 — Non-academic doctorate

demic level goes up. The frequency distribution of scientist as a function of the number of unpublished research projects per scientist is best represented by a negatively orientated curve. The max-

Table : 9. Number of scientific papers published in physics, 1933 - 1966

Year	Total f	cumf	IUFF	ITU	AUFF	METU	KCNAM	EUFF
1964 - 66	26	162	5	—	5	11	5	1
1961 - 63	17	136	9	—	3	4	—	1
1958 - 60	21	119	4	1	4	10	—	2
1955 - 57	42	98	21	1	4	9	—	7
1952 - 54	31	56	17	1	6	6	—	1
1949 - 51	15	25	3	2	6	6	—	2
1946 - 48	3	10	2	1	0	—	—	—
1943 - 45	5	7	1	3	1	—	—	—
1940 - 42	1	2	1	—	—	—	—	—
1937 - 39	0	1	0	—	—	—	—	—
1934 - 36	1	1	1	—	—	—	—	—
1933	0	0	—	—	—	—	—	—
TOTAL	162		64	9	25	46	5	14

imum number of unpublished research papers by a single scientist is nine. Among unpublished reearch work part was financed by international organizations like CENTO and NATO, but the majority of unpublished research received no support either from national or international agencies.

FINDINGS CONCERNING THE ACADEMIC AND EDUCATIONAL PREPARATION OF SCIENTISTS

1. Findings on the scientists' education are as follows (table 10):

(a) The time required for obtaining a B. Sc. degree varies between two and ten years with an average for Group A of 4.51 years. The frequency distribution of the duration of B. Sc. is given below. It represents an almost normal distribution.

Table 10. Years of Education of the Basic Scientists

Number of Scientist	Lenght of Education for B. Sc. degree (in years)
7	2
17	3
337	4
103	5
63	6
8	7
6	8
2	9
1	10

(b) Length of education for B. Sc. degree varies with the area of specialization in basic sciences. Thus the average length of years for B. Sc. degree is 4.00 years in astronomy, 4.33 in mathematics, 4.44 in physics, and 4.68 years in chemistry.

(c) The average length of education for M. Sc. and doctorate degrees are 2.17 and 4 years. The time required for doctorate degree in physics is above the average, in mathematics and the biological sciences it is around the average, for chemistry it is below the average.

(d) The lengths of education for B. Sc. and doctorate vary from one university to the other.

2. Findings on the duration of service at different academic levels are as follows (table 11): The average length of time spent at different academic levels are 8 years at Group B level and 7.28 years at Group C level (table 12).

Table : 11. Average years spent in different academic levels

Area of Specialization		Assistant Professor	Associate Professor	Professor
Mathematics	N*	5	26	16
	X*	3.60	7.12	13.25
Statistics	N			
	X	0.00	0.00	0.00
Physics	N	4	37	22
	X	1.25	8.49	11.68
Astronomy	N		5	2
	X	0.00	9.00	14.50
Chemistry	N	7	40	21
	X	2.86	8.75	10.43
Bio. Sciences	N	3	60	33
	X	3.67	7.07	7.82
Interdiscipl.	N		22	16
	X	0.00	8.27	8.94
Earth Sciences	N	1	8	7
	X	3.00	7.13	7.57
Medicine	N			
	X	0.00	0.00	0.00
TOTAL		20	198	117
Average years		2.85	7.86	10.01

* N = Number of Scientists; X = Mean

The time spent at different academic levels is also related to the area of specialization; thus it is above the average in mathematics and physics and lower in astronomy and chemistry. Promoti-

on from level B to level C is faster at technical universites than at the faculties of science of the universities. The rate of promotion is faster between Groups C and D than it is between Groups B and C.

Table : 12. Average years spent in different academic levels in different institutions

		Inst. code	B.Sc.	M.Sc.	Doctorate	Asst.	Inst.
Science Faculties	N*	33	385	49	140	217	66
Group - I	X*	33	4.45	2.24	3.81	8.20	4.26
Technical Universities	N	34	16	3	18	42	7
Group - II	X	34	4.94	4.00	6.78	8.95	4.86
Schools of M.D.	N	35	69	5	52	58	24
Group - III	X	35	5.04	2.00	3.85	6.78	5.79
Foreign Countries	N	36	64	51	58	3	7
Group - IV	X	36	4.19	1.96	3.52	5.67	2.57
TOTAL N		30	535	108	268	321	105
Average years		30	4.51	2.15	3.96	8.02	4.51

* N = Number of Persons; X = Mean (years)

REGENERATION IN BASIC SCIENCES

The pattern of scientific manpower of Turkey was traced in the esarlier parts of the paper by some analyses of the data collected. It would be useful, and interesting as well, to trace back to the sources which led to the growth observed in order to appreciate the impact of foreign science, the institutions of Turkish science and even the Turkish senior scientists on the scientific development of Turkey.

It would be immediately observed that scientific manpower of Turkey generates from three different sources. The doctors of science that Turkey possesses today, which began to accumulate after 1930 were trained and advised and thus were regenerated as doctors of science, stem from such sources as (1) the centers of science in the foreign countries, primarily Westren countries (2) from visiting foreign scientists in Turkey and with some time lag from (3) the training of senior Turkish scientists. It was as late as 1936-1937 that Turkey had her first two doctors of science—one happens to be in the field of astronomy and was generated under the advisorship of a visiting German scientist and the other one (1936) was the result of a joint advisorship, in the field of mathe-

matics. Approximately two decades after this incidence took place, Turkey trained most of its doctors of science abroad, mainly in France and Germany and also at home under the advisorship of a team of foreign scientists who were invited to the Faculty of Science of the University of Istanbul after the 1933 University Reform. Therefore 16 - 20 years elapsed after the reform before some home grown doctors of science advised by senior Turkish scientists, began to crop up in the scientific milieu of Turkey.

Foreign Trained Turkish Basic Scientists

As far as the foreign trained Turkish doctors of science are concerned, observation of the data (see Table 13) reveal that there were two distinct periods of rapid increase in their number; the first one being at the beginning of the Worl War II and the second beginning by the early part of the First Five Year Plan which occurred following the 1960 revolution.

Although the first rapid increase seems to be due to the war — because many Turkish scientists abroad returned home then — to find a causation or even a high correlation between the second rapid increase and planning activites, however, would require further investigation which is beyond the immediate scope of this study.

The years between 1930 - 36, from the point of training abroad, accounts for what one may term «the period of random noise» where only sporadic occurences of regenerations were observed. The period between 1942 - 49 may be called a «period of near vacuum» when virtually no regeneration was observed. All this suggests that—except perhaps for the 1933 reform act and the planned period of 1962 - 67 — Turkey had no carefully planned policy for training its science doctors abroad.

As the data reveal, among the training countries Germany ranks first whereas France, England and the U.S.A. have more or less equal contributions, thus the latter three occupy more or less the same level in the hierarchy of training. Again it is quite clear from the data that Germany was a distinct source of support of Turkish science at the initial stage of her development. Germany supported Turkish science not only by providing visiting German scientists to serve in Turkey but also by training important numbers of Turkish doctoral candidates of basic sciences. The trend of the data suggests that the impact of France upon Turkish science,

Table 13. Doctor of Science Degrees Received by Turks in Foreign Countries. (1, 2, 3)

Years	1930	31	32	33	34	35	36	37	38	1939	
Regeneration	3 FR[4]	3 GR	7 GR				1 GR		3 GR	6 GR	3 FR
							5 GR			6 GR	7 GR
							1 GR			6 GR	6 GR
										7 FR	
Years	1940	41	42	43	44	45	46	47	48	1949	
Regeneration	3 GR	3 GR				7 SW	1 USA			5 SW	
	3 FR	7GR					5,8 SW			7 ENG	
	3 ENG	7 GR									
Years	1950	51	52	53	54	55	56	57	58	1959	
Regeneration	7 USA	3 USA			5 SW	1 GR		3 USA	5 GR		
	3 ENG				5 USA	1 FR		3 FR			
Years	1960	61	62	63	64	65	1966				
Regeneration	7 USA	1 USA	8 GR	3 ENG	3 USA	1 ENG	3 ENG				
	1 USA	3 FR		1 USA	1 USA	7 ENG	3 SWd				
				3 USA	1 FR	6 ENG	3 ENG				
					5 USA		5 ENG				

1. Turkish scientists working permanently abroad are not included.
2. Scientists with M.D. and technical background are not included
3. Data based on ninty-five per cent of the scientists
4. Number stands for the area (e.g. 400 as 4 astronomy, see appendix) and letter indicates the country where degree was received.

which happened to be the oldest impact, beginning as early as the Tulip era, accentuated in 1926 when a team of French scientists reinforced the staff of IUFF. This influence was thinned with Germany's enormous contributions which occurred when the University Reform Act of 1933 was put into effect. The relatively superior role of German science with respect to its impact on Turkish science continued after the war but seems to be altered recently (1960 and on) by the intensifying impact of Anglo-Saxon science. While the intense impact of German Science—and partially science of France—was felt at IUFF, the impact of Anglo-Saxon science was focused on newly emerging institutions of science such as METU, EAUFF and Hacattepe University. AUFF and EUFF are observed to be under mixed impact with more inclination toward continental science. As I have already acknowledged, to attribute causal relations to the aforementioned observed trends however requires further analyses at policy formulation level in which the analysis of the interaction among the various social, political and economical forces is imperative. Such a task is beyond the immediate scope of the present study.

Findings Concerning Fertility in Turkish Science

Quite interesting findings are obtained by some rather unique analyses of the data collected. The questionnaire constructed for collecting data (Appendix 1) included items which allowed tracing who was whose advisor in his degree work.

The findings are as follows :

1. Approximately fifteen per cent of Turkish scientists were regenerated abroad.

2. The remaining eighty-five per cent were regenerated in the following fashion :

(a) Thirty-six per cent were advised and thus regenerated by visiting foreign scientists of which (i) 2/3 were regenerated in IUFF and a great majority of the remaining were regenerated in AUFF (Faculty of Science, Univerity of Ankara). A very small per cent was regenerated at EUFF (Ege University) and ITU (Istanbul Technical University). (ii) Visiting foreign scientists who served in the faculties of science of the remaining universities (e. g. METU, EAUFF, TTU and Hacettepe) had no contribution as yet.

3. The foreign visiting scientists who regenerated 36 per cent of the 85 per cent of the total Turkish doctors of science was only 1/5 of the total group of scientists who were legally capable of advising thus regenerating young doctors of science.

4. Those scientists either Turkish or foreign who were chair professors (chair professorship is the usual system of hierarchy in most Turkish Universities except recently established ones; e.g. M.E.T.U.) had much higher frequency of advising the doctoral work.

5. The great majority of the visiting foreign scientists who advised thus regenerated young doctors of science were of German nationality.

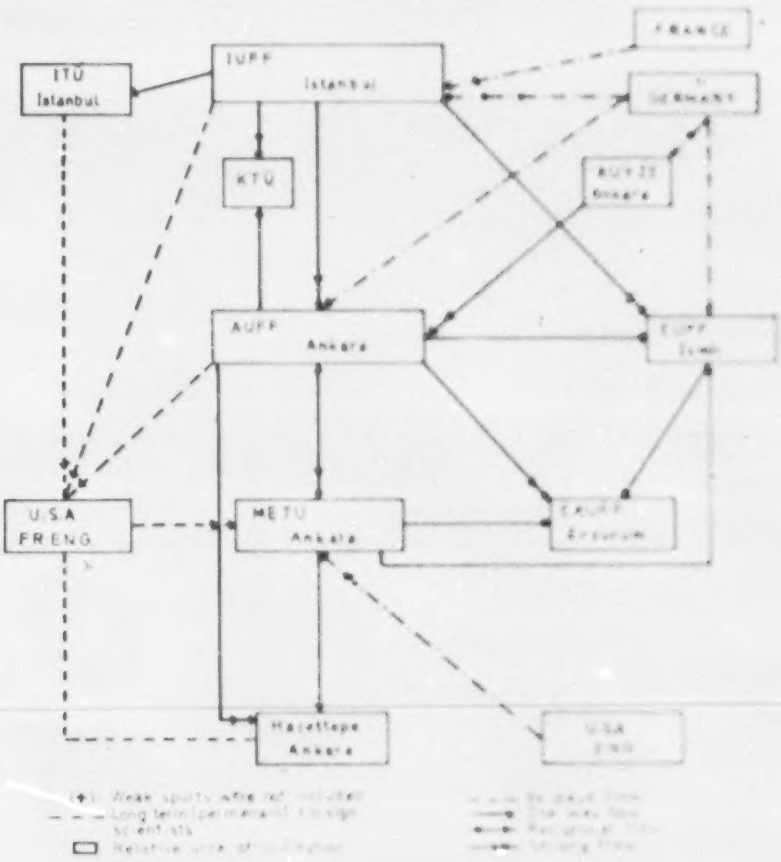
6. At least forty per cent of the senior Turkish scientists have not advised any young doctors of science and thus they had not regenerated Turkish men of science. When this was questioned during the interview made by the investigator, the view that they expressed was that it was not a common practice that doctoral candidates be advised by professors other than those who were chair professors.

7. The distribution of the frequency of advisorship indicates that seventeen per cent of all visiting foreign scientists advised and thus regenerated nearly forty-five per cent of the total number of Turkish scientists. As far as the regenerating Turkish scientists group is concerned the frequency of advisorship was observed to be more evenly distributed among the members of the group.

8. It was most frequently observed that some 16 - 20 years elapsed between the dates when senior scientist had his own doctorate and when the first doctoral candidate was advised by him.

9. Regeneration caused by Turkish scientists occurred as early as 1936 in the field of mathematics as a sporadic incidence because it was not before 1949 when high numbers of quanta were observed. As a matter of fact in 1949 Turkey had seven homegrown and domesticly regenerated Turkish doctors of science spread over such fields of specialization as solid state physics, mathematics, chemistry, physical chemistry and geophysics. Then approximately 1-2 spurts occurred every two-three years of irregular entervals were observed between 1949 and 1966.

The Flow of Scientists Among Centers of Science of Turkey



Institutional Regeneration

When the flow of Turkish scientists are traced from the data it is observed that while IUFF had provided senior and junior scientists for the establishment of a new center of science in Ankara that is Faculty of Science of University of Ankara (AUFF) in the 1942-46 period this second center of science helped the establishment of three new centers such as one in Ankara (METU), one in Izmir (EUFF) and one in Erzurum (EAUFF). The diagram above which was constructed according to the data shows the flow—including the direction of flow—of scientific manpower among the centers of science in Turkey.

STATISTICAL ANALYSES

Three different statistical procedures were used to analyse the findings. They were: (1) testing the significance of personnel samples with respect to their size; (2) the curve fitting processes applied on personnel development curves; (3) test of significance of goodness-of-fit of the observed distributions to theoretical curves.

Test of Significance of Sample Sizes

The sizes of the samples representing all four scientific personnel groups (levels A, B, C, D) were found statistically significant at 0.01 level. Group A', an alternative form of Group A consisting only of Turkish scientists in basic disciplines, was also statistically significant at 0.01 level. The process of testing the level of significance of various samples and results obtained are given at the bottom of the tables (Tables 1, 2, 3, 4) relating to personnel development. Many of the sub-groups representing the different areas of the basic sciences tested were also found statistically significant.

The Findings On Curve Fitting

The results are given as ratios between the minimum number of squares that could be counted beneath the theoretical curve and the corresponding curve of observed results. The general form of development of scientific personnel is expected to be an exponential growth. The equation of the theoretical curves and their reduction lines obtained from the observed distributions of personnel development at Group A' level are given in the table below:

Table 14. Theoretical Equations For Manpower Development

Group or field	Equations		No. of Table in Appendix
	Curve	Reduction Line	
Total Group	$Y = 12.8\ e^{0.72x}$	$Y' = 0.05\,x + 1.1$	21
Math. Group	$Y = 2.6\ e^{0.10x}$	$Y' = 0.05\,x + 1.1$	22
Physics Group	$Y = 1.1\ e^{0.73x}$	$Y' = 0.05\,x + 0.16$	23
Group B (total)	$Y = 10.1\ e^{0.11x}$	$Y' = 0.05\,x - 1.0$	24
» » Math.	$Y = 7.8\ e^{0.62x}$	$Y' = 0.01\,x + 0.89$	25
» » Physics	$Y = 1.2\ e^{0.12x}$	$Y' = 0.05\,x - 0.06$	26
» » Chemistry	$Y = 1.6\ e^{0.12x}$	$Y' = 0.05\,x + 0.22$	27
» » Bio. Sciences	$Y = 3.4\ e^{0.11x}$	$Y' = 0.05\,x + 0.53$	28

45

Test of Significance on Curve Fitting

The Kolmogorov - Smirnov (KS) Test was applied to assess the significance of the differences occurred between the theoretical and observed frequency distributions of manpower development during the past thirty three years of Turkish science.

As the tables (Tables 29 - 36, Appendix) prepared according to the KS Test of analysis indicate, all the observed frequency distributions at all personnel levels and sub-groups tested departed significantly from the expected or theoritical distributions and thus were considered to be non-fitting to exponential growth curve of scientitifc manpower.

V

CONCLUSIONS

The application of analytical approach to the study of scientific development has led the discipline called «science of science» to a stage which «resembled rather strongly the stage of astronomy» when Kepler formulated laws of planetary motion from Tycho Brache's data.[55] While astronomy was developed later by Newton's universal laws thus became capable of explaining the causes of such motion, science of science is as yet not so mature to provide us a causal model fitting the observed behaviours of science and scientific development.

Inspite of that shortcoming, however, science of science can tell us, more than ever before, how science behaves, what relations exist between size of science and wealths of nations.[56, 60] By means of these rather recent analyses that the findings arrived in this study can be compared with those of theoretical and actual findings achieved by others. In the following parts, some comparisons are made of the present situation and historical development, and also some generalizations concerning Turkish scientific growth are drawn.

COMPARING THE PRESENT SITUATIONS

The comparisons concerning the present situations were made with respect to size of science and spendings on science, the shape of scientific manpower pyramid and feedback in scientific institutions.

Spending on Science

As Tanner puts forward scientific manpower, if well utilized, «may generate wealth many times in excess of the cost of production».[61] The close relation between spending on science and the level of economic development has been already mentioned. The figures calculated by O.E.C.D. for 1952 which are given below clearly indicate that the advanced countries allocate at least one per cent of their GNPs to research and development.[64]

Spending on Research and Development
(per cent of G.N.P.)

United States	3.1	France	1.5
United Kingdom	2.2	Germany	1.3
Netherlands	1.8	Belgium	1.0

The minimum share of G.N.P. that should go to research should be around one per cent.[56] Actually greater shares of the allocations indicated above go to development efforts, especially in the case of United States. As far as Turkey is concerned, acrording to the calculation I made in 1963 approximately 0.56 per cent of Turkey's G.N.P. was allocated to science and science education.[63] When this figure was corrected to include only research activities, we see that Turkey allocates 0.1 per cent of her G.N.P. to basic and applied research. This amount is only one tenth of what Turkey should provide to science for a normal growth of science.[56, 62] As a matter of fact when G.N.P. and size of science are correlated for different nations, it is seen that Turkey's size of science is equal to science of Lebanon while the economic size of Lebanon is more or less one tenth of Turkey. And if Turkey allocated the expected one per cent of her G.N.P. to science and made effective use of this allocation, her size of science would be equal to that of Denmark which is almost 10 times of the size of science of Turkey.[56]

Shape of Manpower Pyramid

Both research needs and supply-demand calculations made on basic sciences require that the form of manpower allocations to various academic levels should construct a manpower pyramid at the base of which assistants are located. The findings of this study reveal (see pp. 15-16) that distribution of scientific manpower in various academic levels did not form a manpower pyramid.

When the distribution of scientific manpower in various academic levels of Turkish Universities is compared with those of England and France (shown at the table blow), it is seen that both France and England possess a scientific manpower pyramid while Turkey has a distorted form of distribution. The present form of scientific manpower pyramid of Turkey has great similarity with that of France in 1928.

Table 14. Comparisons of Forms Scientific Manpower of Different Countries

	Turkey	England [6] (Edinburgh Univ)	France [7] (1963/64)	(1928)
Lecturers	364	189	4731	246
Senior Lecturers	52	82	878	76
Professors and Assoc. Prof.	268	24	498	192

As far as the distributions of scientists with respect to their sex is concerned, uniquely enough, *thirty seven per cent* of all basic scientists in Turkey are female. Despite their great efforts many countries (e.g. Russia) could not achieve this relatively rather high ratio between the sexes. The percentages of female scientists given below clearly illustrate Turkey's unique position.

Table 15. Sex Difference in Basic Sciences
(Per cent of female scientists)

Country	Percent	Country	Percent
Turkey	37	Canada (1)	7.4
U.S.S.R. (3)	21	U.S.A. (2)	11

(1) As enrollments in Ph.D. of science [66]
(2) Social sciences inclusive [65] (3) A close estimate

Feedback in Training Institutions

According to the data provided by Wilson on American Scientists, the input - output ratios of scientists in the training institutions vary from one field to another.[64] While a very great majority (90 per cent) of Ph.D.s in history, political sciences, sociology remain in the training institutions, again a very high per cent of Ph.D s in such disciplines as chemistry, engineering and psychology opt out of an academic career.

As far as the basic sciences are concerned, a comparison of the feedbacks which were observed in Turkey and in the U.S.A. are given at the table below:

Table 16. Per Cent of Feedback in Different Fields

Country	DISCIPLINES Math.	Phys.	Chem.	Bio. Sc.
Turkey	90	92	40	26
U.S.A.	68	39(*)	24	64

(*) Actually university influx changed by time and was fifty five per cent in 1964-66, forty seven per cent in 1958-60 periods.[65]

The differences observed between the two countries with respect to the magnitudes of feedback in different areas of basic sciences may be attributed to the differences existing between the levels of industrialization and the need for specialization in the two countries. It is normally expected that the U.S.A. would have a relatively much higher level of absorption of science doctors. The differences of feedback observed among the different fields of science, however, indicate that while in some areas of basic sciences (e.g. chemistry) there is maximum output and maximum feed back (e.g. mathematics) in the training institutions of both the U.S.A. and Turkey, the feedback ratios in physics and biological sciences, on the other hand, vary between the two countries in such a fashion that physics indicated much higher feedback and biology a much higher output in Turkey than those observed in the U.S.A. The difference observed between the two countries, at least for the case of physics, may be due to the fact that the demand for doctors of science specialized in physics is not yet appreciable in private or public sectors of Turkey except the training institutions where the demand for that manpower has not been fully met. This appears to be a common attribute for all the less developed countries.

Duration of Training and Service in Academic Levels

Half of the Turkish basic scientists reached full professorships 15 to 28 years after receiving the doctorate. A survey made on a sample of 10,000 American men and women Ph.Ds. reveal that this duration was 10 to 12 years [65] in the U.S.A. According to the same study «the advancement has been most rapid in the physical sciences, slowest in the humanities-arts-professions group». Considering that the basic science group requires a still lesser time than 10 years to reach full professorship in the U.S.A., it is obvious that advancement in Turkish science group was at least two times slower than it has been in the U.S.A.

COMPARISONS ON HISTORICAL DEVLOPMENTS

As far as the Western societies of the world are concerned, the scientific development which they have gone through represents a unique pattern. Science in the U.S.A., Canada and Japan has followed more or less the same path of development. In all these societies, in the initial period of their scientific development, the impact of the science of relatively more developed nations was strongly felt. For example, in the U.S.A. graduate education, which has been the main source of regenerating scientific manpower, was under a strong impact of German science in its initial period.[65] As late as the beginning of the 20th Century the United States kept sending its young scientists to Europe for training, while at the same time some domestic institutions of science (e.g. Johns Hopkins, 1876) were reorganized under the guidance of German science. In these dates more or less the same trend was observed in Japan in the Meiji era. In Japan and in Canada at a bit later date, that is during the first two decades of the 20th century, the impact of more advanced foreign science was strongly felt. Canada sent its young scientists to the U.S.A. for training because the U.S.A. was then comparably more advanced in science. The most frequently observed pattern of scientific development seems to follow the subsequent stages: beginning with having visiting foreign scientists while sending junior scientists to be trained abroad in scientifically advanced countries; then reaching the critical size of trained scientists of their own which was followed by a period of regeneration of home grown scientists and then reaching a critical size of home grown scientific manpower which is necessary for take-off for exponential growth.

One observes more or less an identical trend with those of the Western countries in the development of Turkish science. The first significant and overall attempt that Turkey made in having visiting foreign scientists to teach at home while at the same time sending young Turkish scientists to be trained abroad began in the late twenties (1926) and early thirties (1933) of the present century, despite the fact that translation activities of foreign work of science in Japan and in the Ottoman had begun more or less at the same dates. As far as the dates of initial attempts are compared it is seen that Turkey began bu scientific endeavour 60-70 years later than Japan and the U.S.A. and 30-40 years later than Canada.

When the dates of having home-grown doctors of science are compared, it is readily observed from the table below that the time gap between Turkey and other nations is more unfavorable than the gaps observed between the dates of initiating period of scientific post graduate learning.

Table 17. Comparison of Dates of First Home Grown Doctors of Science in Some Countries

Country	Institution	Years of first Dr. of Science	Field of Speciality
U.S.A. (1)	Yale Univ.	1863	Physics
Japan [58]	Edo (Tokyo) Univ.	1863	Science
Canada [56]	McGill Univ.	1906	(5) Chemistry
			(1) Physics
			(1) Geology
Turkey	Univ. of Istanbul (IUFF)	1949(2)	Chemistry, Physics
»	Univ. of Ankara (AUFF)	1949(2)	Math., Geology
»	Ege University (EUFF)	1963(2)	Mathematics, Bio. Sc.
»	Higher Agricultural School, Ankara	1947	Bio. Sc.

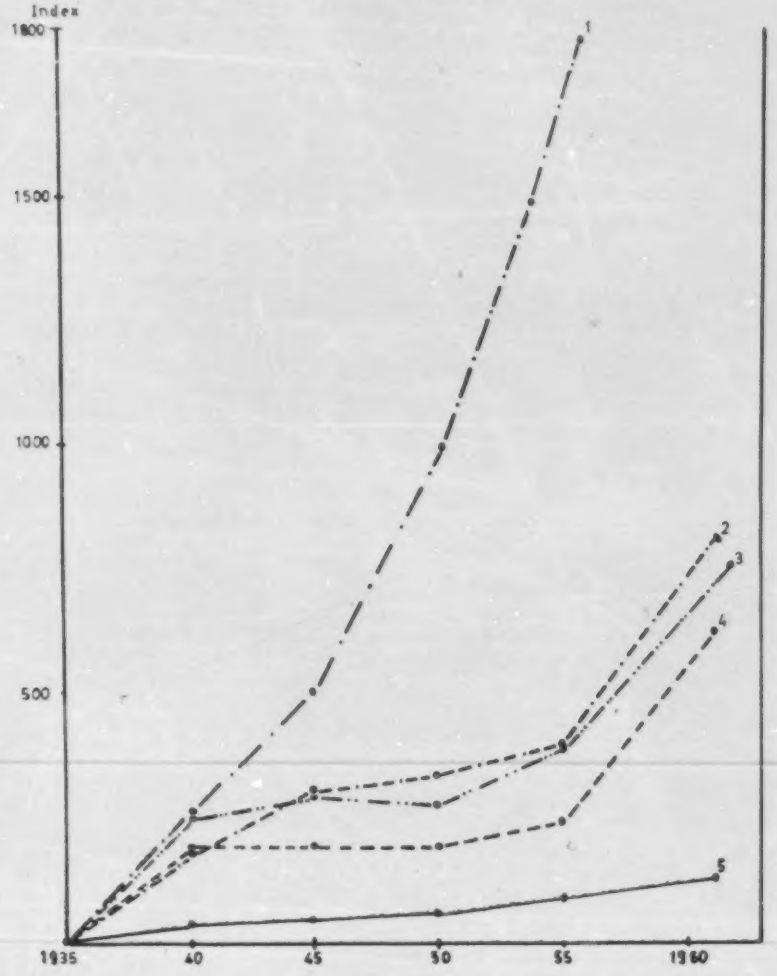
(1) It is interesting to note that W. Gibbs was one of the first Americans to obtain a Ph.D. degree. He spent 1866 - 69 in Europe (Paris, Berlin, Heidelberg) and he was appointed as a professor of theoretical physics without pay. The French Academy which was then assisting Johns Hopkins University to formulate a staff recruitment policy asked W. Gibbs to work as a non-salaried leading physicist there.[73]

(2) Earlier cases of joint advisorship of Turkish and foreign professors were not included in this classification.

TRENDS IN GROWTH OF POPULATION, EDUCATION AND DOCTORS OF SCIENCE

When the rates of growth in Turkish population, educated population and doctors of science are compared (Graph - 6) it is

Graph 6. Growth in Population, Education and Doctors of Science in Turkey.



1. Dr. of science
2. Higher Ed. enroll.
3. Sn. H. S. enroll.
4. Jr. H. S. enroll.
5. Population

observed that the growth rate increases as the level of education of the population goes up.

Between the years 1927 - 1960, while Turkish population has only doubled [67] junior high school enrollments increased six times, senior high school population increased seven times, and the number of science doctors increased almost by a factor of twenty.

As the graph reveals there were two distinct periods of rapid growth which accurred before and after the World War II. The war persod negatively affected the rates of growths in population, educated population and doctors of science, yet the highest depreciation was observed in population and high school enrolments. The trend in the growth of educated population between 1935 - 1940 was such that their growth was much faster than the growth in total population of Turkey.

It is unfortunate to observe that the relatively slower growth which occured in population in 1940 - 1950 period was not utilized as an opportunity for closing the ever existing gap between school age population and school enrolments.

As far as the ratios between numbers of scientists and the total population is concerned the following trend was observed for 1935 - 1965 period.

Table 18. Trend of Doctors of Science in Per Million of Population.

	1935	1940	1945	1950	1955	1960	1965
Scientists	11	37	70	113	228	302	400
Population (10^6)	16.2*	17.8	18.1	21	24	27.8	32
Scientists Per Million of Population	1**	1	4	5	10	11	13

(*) Per 1.5 million of population
(**) Rounded figures

How does Turkey's scientists ratio to her population compare with other nations? The figures given below clearly indicate that Turkey has a lower standing than [redacted] U.S.A., England, Canada and USSR.

Table 19. Comparison of Scientists Per Million of Population*

Country	Number of Ph.D. degrees awarded	Number of scientists per million of population
Turkey	228	10
Great Britain	900	18
U.S.A.	3500	21
USSR	4500	21
[redacted]	[redacted]	[redacted]
Canada	270	18.5

(*) Figures represent 1955 situation.[68]

Noting that the year 1955 corresponds to an after war high rate of growth in Turkish science, we were still about 50 per cent lower than some advanced societies as far as scientific output is concerned. This comparison will serve for as a criterion attribute to draw some generalizations concerning the pattern of scientific growth of Turkey which will be treated right below.

VI

GENERAL DISCUSSION

In the light of the findings obtained in this study the following generalizations may be drawn concerning the pattern of scientific development observed in Turkey in the past 33 years:

1. After an orderly and carefully planned beginning in 1933, Turkey's scientific development was interrupted by World War II and was not rebalanced until 1955 and afterwards. Two distinct periods of rapid development occured; one before the war and the other after the war. The period of growth after war was rather rapid but has not reached an exponential pattern as yet.

2. The pattern that Turkish science has gone through during the past 33 years was a typical pattern of scientific development that many western nations have already gone through. This pattern may be simplified as having the following stages: Training abroad ⟶ Importing foreign scientists ⟶ Having foreign trained domestic scientists ⟶ Having home grown scientists ⟶ Reaching the critical size ⟶ Reaching the internationally accepted standards of science and ⟶ Take-off for exponential growth.

At her present stage of development Turkish science struggles to reach critical size and internationally accepted standards in her effords for take-off.

3. At the present stage of her scientific manpower development, Turkey's annual output of scientists is nearly half of what she should regenerate in order to reach a critical size for take-off. The primary step towards a balanced and exponential growth in the scientific manpower, as it is true of any country which adopted an exponential growth pattern, is that the Turkish scientific manpower should multiply by a factor of two in every ten years period. This simply means that one tenth of the total manpower should be added annualy to the existing scientific personnel. Considering that Turkey had a total of 420 scientists in 1966, 42 new scientists should be added by the end of 1966, 47 by the end of 1967, and 75 by the end of Second Five Year Planned Period (1972).

4. Even if the quantitative dimension of the exponential growth is met, some qualitative requirements of the take-off stage should also be actualized. The most fundamental qualitative requirement in this direction is to upgrading the quality of the product of science in order to meet the supranational standards of scientific publications. According to a very recent study [55] where scientific publications (papers of the world nations) are compared, only 48 Turkish basic scientists appeared as contributing scientists to the internationally accepted body of science in 1967. This figure, even, is a bit bigger than what it should be because it includes scientists in the applied fields such as medicine and engineering it represents only one ninth of the total Turkish scientists and thus clearly indicates how severe the problem of quality that Turkish scientific growth envisaged.

5. Along with the aforementioned shortcomings, the analysis of Turkey's scientific growth has indicated that the impact of foreign science which was observed as training abroad and as regeneration at home actualized by visiting foreign scientists supersedes the contributions of Turkish doctors of science both in terms of fertility and productivity.

6. The present system of chair professorship seems to have a limiting effect on the total regenerating power and of the regeneration by Turkish scientists since many chairs are occupied by foreign visiting scientists and many non-chair professors have advised no or an insignificant number—only one doctor of sciences

was regenerated in every 20 years after the professor received his own doctorate—of doctoral candidates.

7. According to the rules and regulations which are in effect, at least at the majority of the universities, a doctor of science cannot advise a doctoral candidate unless he is a full professor. The findings of this study indicate that half of the Turkish basic scientists reached full professorships 15 to 28 years after receiving the doctorate. Since science doubles in every ten to fifteen years, it is a simple fact that when a Turkish scientist is engaged in advising doctoral work, he can no longer make use of the body of knowledge that he acquired while he was doing his own doctoral work. If this particular man of science was given nothing but a chance of teaching at undergraduate level, his only chance of tracing the advancements that were taking place in his field would be determined by his own interest and initiative, which in most cases are not likely to be created due to poor milieu for flourishing of science.

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APPENDIX

Directions for Scientific Personnel Questionnaire

I. Objectives. This questionnaire aims to collect data necessary for a systematic investigation of scientific development of Turkey in basic sciences from a historical perspective. It covers the period beginning with 1933 and reaching the present time, 1966. The data includes the number of scientific personnel, their «fertility» — that is, regenerating new scientific personnel — and their productivity based on the number and type of publications and research. The data, when treated, will lead to the establishment of a pattern of scientific development in Turkey since 1933. The research is supported by the Scientific and Technological Research Council of Turkey.

II. Coverage. The questionnaire includes questions related to personal data, training, service, research and publications of scientific personnel.

III. Terminology.

1. Basic Sciences — includes mathematics, astronomy, physics, chemistry, biological sciences, and interdisciplinary areas in general, and the subtitles given in the list attached.
2. Eclectic Pamphlets — publications of limited volume containing the collection of the views of Turkey's scientists stated on a general or specific issue of science.
3. Number of Reference — the total number of sources referred to by the author for each research paper he has published.
4. Number of Pages — denotes total number of pages of the text excluding appendices.
5. Original Essay — an original treatment of a problem or problems of science which brings about a unique synthesis.
6. Field of Specialization — specific area of science in which the majority of scientific activities of the scientist are found.

IV. Directions. In answering the questionnaire please follow the rules below:

1. For sex put an X in the space provided.
2. For your field of specialization write two code numbers, one for general, and another for specific field of specialization which you fit yourself. Code numbers are given on the sheet attached. If your area of specialization is not indicated in the list, write the code numbers for 'other', then specify your field of specialization.
3. Please print the titles of your theses.
4. Use code numbers for major and minor fields of training and instruction or service.
5. Give the name(s) of the periodical(s) in which your research paper(s) or article(s) were published.

V. Mailing. If you are a visiting professor and/or a scientist in Turkey, after responding please return the questionnaire to the Dean of the Faculty in which you serve.

If you are abroad kindly mail your questionnaire to the researcher's following address:

Y. Prof. Dr. A. Kemâl Özinönü
Faculty of Arts and Sciences
Middle East Technical University
Orta Doğu Teknik Üniversitesi
Ankara, Turkey.

All the information received will be kept confidential. We are greatly indebted for your cooperation.

CODE: FORM - AKÖ$_{a:}$

SCIENTIFIC PERSONNEL QUESTIONNAIRE

Answered by: Date:

Nationality:

I. Personal Data

Surname, Name:

*Field of Specialization: General: Specific:

Academic Title:

Year of Birth:

Sex: Male Female

II. Academic Training

	Years attended	Major	Minor	Educ. Institution	Name of Adviser for Ph.D.
B.Sc.	19 - 19				
M.Sc.	19 - 19				
Ph.D.	19 - 19				
Other	19 - 19				
Name of Theses:	M.S.				
	Ph.D.				

* Please write the code numbers of your areas of specialization which you will locate on the attached specialities list.

III. Academic Service:

	Year	Institution	Field of Specialization
Instructor	19 - 19		
Assistant	19 - 19		
Assistant Prof.	19 - 19		
Assoc. Prof.	19 - 19		
Professor	19 - 19		

IV. Publications:

a. Books	Names (Original + Turkish)		Year of Publication and Publisher	No. of Pages
b. Original Essays		Name	Year of Publication and Publisher	No. of Pages
c. Ecletic Essays of pamphlets		Name	Publisher and Year of Publication	No. of Pages

b. Research Papers*

Area of Specialization	Published in	Year of Publication	Pages	No. of References Turkish/Foreign

V. Unpublished Research

Area	Problem	Duration	Financing Institution

* If the number of articles exceds 20 please attach a list.

VI. Training of Graduate Students

A. Training of Doctoral Students

Please write the names of the doctoral candidates who received a doctoral degree under your advisorpship since 1933.

Name of the Candidate	Code no. of Field of Speciality of Thesis	Duration of Training	Present Employing Inst.

B. Training of Master Students

Write the number of graduate students whom you have supervised during their education fo the Master's degree.

(Appendix 1 cont)

Specialties List for Use with
Questionnaire of Scientific Personnel

0100 MATHEMATICS
0101 Algebra
0102 Analysis and Functional Analysis
0103 Geometry
0104 Logic (symbolic)
0105 Mathematics of Resource Use (e.g. logistics, programming)
0106 Number Theory
0109 Probability
0110 Other (Specify)

0200 STATISTICS
0201 Analytical Statistics
0202 Biometrics
0203 Econometrics
0204 Demography
0205 Other (Specify)

0300 PHYSICS
0301 Acoustics
0302 Atomic and Molecular Physics
0303 Electromagnetism
0304 Elementary Particles
0305 Mechanics
0306 Nuclear Physics
0307 Optics
0308 Physics of Fluids
0309 Solid State Physics
0310 Thermal Physics
0311 Physics, other (specify)

0400 ASTRONOMY
0401 Astrometry
0402 Astrophysics
0403 Space Astronomy
0404 Statistical Astronomy
0405 Astronomy, other (Specify)

0500 CHEMISTRY
0501 Analytical Chemistry
0502 Inorganic Chemistry
0503 Organic Chemistry
0504 Related Chemical Specialties (e.g. Electro Chemical operations)
0505 Chemistry, other (specify)

0600 BIOLOGY
0601 Anatomy
0602 Botany
0603 Ecology
0604 Entomology
0605 Genetics
0606 Microbiology
0607 Pathology
0608 Physiology
0609 Plant Pathology
0610 Virology
0611 Zoology
0612 Biology, other (specify)

0700 INTERDISCIPLINARY SPECIALTIES
0701 Agricultural and Food Chemistry
0702 Biochemistry
0703 Biophysics
0704 Physical Chemistry
0705 Electronics
0706 Other (Specify)

General Areas : 0100, 0200, 0300, 0400, etc.
Specific Areas : 0101, 0201, 0301, 0401, etc.

Appendix 2. System of Coding Employed At the Questionnaires, IBM Cards and Tables of This text

I — General Coding of Regions

Istanbul region — 0I
Ankara region — 0II
Erzurum region — 0III
İzmir region — 0IV
Trabzon region — V
Foreign Countries — VI
Turkey (other) — 28

II — Coding of Institutions:

Universities, Faculties and Other Institutions of Basic Sciences and of the scientists in those institutions:

Code no. Region	Code no. Institution	Abbreviation	Name of Institution	Scientists Codes Begin	End
Istanbul					
0I	01	IUFF	Univ. of Ist. Fac. of Sci.	001	189
	02	ITU	Tech. Univ. of Ist.	190	299
	04	IUTF	Fac. of MD.		
	03	IUEF	Univ. of Ist. Fac. of Dent.	300	
	22	KÇNAM	Küçükçekmece Nuclear Research Center	402	406
Ankara					
0II	12	AUFF	Univ. of Ankara Fac. of Science.	001	
	13	AUTF	Univ. of Ank. Fac. of MD.		
	14	AUHTF	Univ. of Ank. Hacettepe		
	29	GTA	Gülhane Sch. of MD.		
	33	AUVT	Univ. of Ank. Fac. of. Vet.		
	15	METU	Middle East Tech. Univ. (Eng.)		
	16	METUFF	Middle East Tech. Univ. Fac. of Sc.		
Erzurum					
0III	17	EAUFF	Erzurum Atatürk Un. Fac. of Science.	001	
	18	EAUTF	Erz. At. Un. Fac. of MD		
Izmir					
0IV	19	EUFF	Ege Univ. Fac. o. Sc.	001	
	20	EUTF	Ege Univ. Fac. o. Md.		
Trabzon					
0V	21	KTU	Trabzon Tech. Univ.	001	
	28	Turkish (Other)		001	
				001	
0VI	23	France			
	24	U.S.A.			
	25	Germany			
	26	England			
	27	Foreign	Countries (other)		

Appendix — 3

Table 20. Frequency and Cumulative Frequency Distributions of Manpower Development in Different Fields of Basic Sciences at GROUP A' LEVEL.

Areas / Years	Total f	Total cf	100 f	100 cf	300 f	300 cf	400 f	400 cf	500 f	500 cf	600 f	600 cf	700 f	700 cf	800 f	800 cf	900 f	bb
1967	12	430	4	61		62			3	101	2	96	1	27			9	
1964-66	61	418	5	57	3	62	2	11	17	98	12	94	3	26	10	37	4	
1961-63	55	357	8	52	12	54	1	9	10	81	13	82	5	23	2	27	4	
1958-60	43	302	7	44	6	42	0	8	12	72	12	69	1	18	1	25	5	
1955-57	47	259	7	37	5	36	0	8	14	60	13	57	2	17	4	29	2	
1952-54	51	212	8	30	9	31	3	8	9	46	9	44	7	15	3	20	3	
1949-51	72	161	10	22	11	22	4	5	18	37	10	35	4	8	7	17	7	1
1946-48	19	89	3	12	2	11	0		5	19	2	25	1	4	2	10	0	1
1943-45	16	70	2	9	0	9	0		4	14	5	20	0	3	3	8	1	1
1940-42	25	54	3	7	4	9	9		7	10	6	15	2	3	3	5	0	
1937-39	15	29	1	4	3	5	1		0	3	8	9	0	1	1	2	1	
1934-36	9	14	3	3	0	2			2	3	1	1	1	1	1	1	1	
-33	1	5			0	2			1	1								
Before 1933	4	4			2	2									1			

(b)

Sample:
% p/q:
(p) Table value:
(p) Observed value:
Level of Significance:

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4. APPENDIX

Tables 21-28. Curve Fitting Statistics

Table 21. Total group at group 'A' level

(Years) X	(Manpower) Y	log Y=Y'	XY'	X^2	Y_c
0	5				
3	9	0.9542	2.8626	9	18.29
6	24	1.3802	8.2812	36	26.07
9	49	1.6902	15.2118	81	37.15
12	66	1.8195	21.8340	144	52.91
15	85	1.9294	28.9410	225	75.39
18	156	2.1931	39.4758	324	107.40
21	207	2.3160	48.6360	441	153.10
24	254	2.4048	57.7152	576	218.00
27	297	2.4728	66.7656	729	310.70
30	352	2.5465	76.3950	900	442.60
33	413	2.6160	86.3280	1,089	630.50
Total		22.3227	452.4462	4,554	

Table 22. Mathematics sub-group at group 'A' level

(Years) X	(Manpower) Y	log Y=Y'	XY'	X^2	Y_c
3	3	0.4771	1.4313	9	3.538
6	4	0.6021	3.6126	36	4.827
9	7	0.8451	7.6059	81	6.586
12	9	0.9542	11.4504	144	12.270
15	12	1.0792	16.1880	225	8.968
18	22	1.3424	24.1632	324	16.73
21	30	1.4771	31.0191	441	22.78
24	37	1.5682	37.6368	576	31.16
27	44	1.6435	44.3745	729	42.51
30	52	1.7160	51.4800	900	58.01
33	57	1.7559	57.9447	1,089	79.16
Total		13.4608	286.9065	4,554	

Table 23. Physics sub-group at group 'A' level

(Years) X	(Manpower) Y	log Y = Y'	XY'	X^2	Y_c
0	2	0.0000			
3	0	0.0000	0.0000	9	2.083
6	3	0.4771	2.8626	36	3.031
9	7	0.8451	7.6059	81	2.411
12	7	0.8451	10.1412	144	6.418
15	9	0.9542	14.3130	225	9.340
18	20	1.3010	23.4180	324	13.59
21	29	1.4624	30.7104	441	19.77
24	34	1.5315	36.7560	576	28.77
27	40	1.6021	43.2567	729	41.88
30	52	1.7160	51.4800	900	60.92
33	60	1.7782	58.6806	1,089	88.65
Total		12.5127	279.2244	4,554	

Table 24. Total group at group 'B' level

(Years) X	(Manpower) Y	log Y = Y'	XY'	X^2	Y_c
3	9	0.9542	2.8626	9	14.29
6	18	1.2553	7.5318	36	20.18
9	36	1.5563	14.0067	81	28.47
12	45	1.6532	19.8384	144	40.20
15	56	1.7482	26.2230	225	56.74
18	111	2.0453	36.8154	324	80.09
21	149	2.1732	45.6372	441	113.1
24	186	2.2695	54.4080	576	159.6
27	223	2.3483	63.4041	729	225.3
30	267	2.4265	72.7950	900	318.0
33	323	2.5092	82.8036	1,089	448.8
Total		20.9392	426.3258	4,554	

Table 25. Mathematics sub-group at group 'B' level

(Years) X	(Manpower) Y	log Y = Y¹	XY¹	X²	Y_c
0	0				
3	3	0.4771	1.4313	9	8.414
6	3	0.4771	2.8626	36	9.046
9	5	0.6990	6.2910	81	9.727
12	7	0.8451	10.1412	144	10.46
15	9	0.9542	14.3130	225	11.25
18	16	1.2041	21.6738	324	12.37
21	20	1.3010	27.3210	441	13.00
24	24	1.3802	33.1248	576	13.98
27	28	1.4472	39.0744	729	15.03
30	34	1.5315	45.9450	900	16.18
33	39	1.5911	52.5063	1,089	17.38
Total		11.9076	254.6844	4,554	

Table 26. Physics sub-group at group 'B' level

(Years) X	(Manpower) Y	log Y = Y¹	XY¹	X²	Y_c
6	2	0.3010	1.8060	36	2.323
9	7	0.8451	7.6059	81	3.295
12	7	0.8451	10.1412	144	4.673
15	8	0.9031	13.5465	225	6.628
18	20	1.3010	23.4180	324	9.401
21	29	1.4624	30.7104	441	13.34
24	34	1.5315	36.7560	576	18.91
27	38	1.5798	42.6546	729	26.83
30	50	1.6990	50.9700	900	38.06
33	60	1.7782	58.6806	1,089	53.98
Total		12.2462	276.2892	4,543	

Table 27. Chemistry sub-group at group 'B' level

(Years) X	(Manpower) Y	log Y = Y'	XY'	X^2	Y_c
0	0				
3	2	0.3010	0.9030	9	2.349
6	2	0.3010	0.1860	36	3.357
9	5	0.6990	6.2910	81	4.796
12	7	0.8451	10.1412	144	6.852
15	10	1.000	15.000	225	9.792
18	23	1.3617	24.5106	324	13.99
21	28	1.4472	30.3912	441	19.99
24	36	1.5563	37.3512	576	28.57
27	43	1.6335	44.1045	729	40.83
30	48	1.6812	50.4360	900	58.33
33	61	1.7853	58.9149	1,089	83.35
Total		12.6113	278.2296	4,554	

Table 28. Biological sciences sub-group at group 'B' level

(Years) X	(Manpower) Y	log Y = Y'	XY'	X^2	Y_c
0	0				
3	3	0.4771	1.4313	9	4.708
6	7	0.8451	5.0706	36	6.539
9	11	1.0414	9.3726	181	9.084
12	14	1.1461	13.7532	144	12.62
15	17	1.2304	18.4560	225	17.54
18	28	1.4472	26.0496	324	24.36
21	41	1.6128	33.8688	441	33.85
24	54	1.7324	41.5776	576	47.02
27	67	1.8261	49.3047	729	65.33
'30	81	1.9085	57.2550	900	90.70
33	97	1.9868	65.5644	1,089	126.1
Total		15.2539	321.7038	4,554	

Tables 29-36: Statistics based on the Kolmogorov-Smirnov Test of significance

Table 29. Group total at group 'A' level

Cf_o Y	Cf_e Y_c	Cp_o Y/N	Cp_e Y_c/N_c	Cp_o-Cp_e
9	18.29	0.021	0.029	−0.008
24	26.07	0.058	0.000	+0.017
49	37.15	0.186	0.059	+0.127
66	52.91	0.160	0.084	+0.076
85	75.39	0.206	0.120	+0.086
156	107.40	0.378	0.170	+0.208
207	153.10	0.501	0.242	+0.259
254	218.00	0.615	0.345	+0.270
297	310.70	0.719	0.491	+0.228
352	442.60	0.852	0.702	+0.150
413	630.50	1.000	1.000	0.000
N=413	N_c=630.5			D = 0.270

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D
0.067	1.63/413=0.08	0.270	* *

* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 30. Mathematics sub-group at group 'A' level

Cf_o Y	Cf_e Y_c	Cp_o Y/N	Cp_e Y_c/N_c	Cp_o-Cp_e
3	3.5	0.053	0.044	+0.009
4	4.8	0.069	0.061	+0.009
7	6.6	0.123	0.083	+0.040
9	9.0	0.158	0.114	+0.044
12	12.3	0.211	0.155	+0.056
22	16.7	0.386	0.211	+0.175
30	22.8	0.526	0.288	+0.238
37	31.2	0.649	0.394	+0.255
44	42.5	0.772	0.537	+0.235
52	58.0	0.912	0.732	+0.180
57	79.2	1.000	1.000	0.000
N=57	N_c=79.2			D=0.255 ob.

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D
0.180	0.215	0.255	* *

* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 31. Goodness of fit for physics sub-group at group 'A' level

Cf_o Y	Cf_e Y_c	Cp_o Y/N	Cp_e Y_c/N_c	Cp_o-Cp_e
0	2.08	0	0.023	−0.023
3	3.03	0.050	0.034	+0.016
7	4.41	0.117	0.050	+0.063
7	6.42	0.117	0.072	+0.035
9	9.34	0.150	0.105	+0.045
20	13.59	0.333	0.153	+0.180
29	19.77	0.483	0.223	+0.260
34	28.77	0.567	0.325	+0.232
40	41.88	0.667	0.472	+0.195
52	60.92	0.867	0.687	+0.200
60	88.65	1.000	1.000	0.000
N=60	N_c=88.65			D=0.260

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.174	0.210	0.260	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 32. Goodness of fit for total group at group 'B' level

Cf_o Y	Cf_e Y_c	f_o/N 1/NXY	Cf_e/N $1/NXY_c$	Cp_o-Cp_e
9	14.29	0.02480	0.03182	−0.0070
18	20.18	0.04960	0.04494	0.005
36	28.47	0.09918	0.06344	0.036
45	40.20	0.12398	0.08957	0.040
56	56.74	0.15428	0.12643	0.028
111	80.09	0.30581	0.17845	0.127
149	113.1	0.41050	0.25200	0.159
186	159.6	0.51243	0.35561	0.157
223	225.3	0.61437	0.50200	0.112
267	318.0	0.73559	0.70856	0.027
363	448.8	1.00007	1.000	0.000
N=363	N_c=488.8			D=0.159

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.07	0.086	0.159	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 33. Goodness of fit for mathematics sub-group at group 'B' level

Cf_o Y	Cf_e Y_c	Cp_o Y/N	Cp_e Y_c/N_c	Cp_o-Cp_e
3	8.41	0.077	0.484	—0.404
3	9.05	0.077	0.521	—0.444
5	9.73	0.128	0.560	—0.432
7	10.46	0.179	0.602	—0.423
9	11.25	0.231	0.647	—0.416
16	12.37	0.410	0.712	—0.302
20	13.00	0.513	0.748	—0.235
24	13.98	0.615	0.804	—0.189
28	15.03	0.718	0.865	—0.147
34	16.18	0.872	0.931	—0.059
39	17.38	1.000	1.000	0.000
N=39	N_c=17.38			D=0.444

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.217	0.261	0.444	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 34. Physics sub-group at group 'B' level

Cf_o Y	Cf_e Y_c	Cp_o Y/N	Cp_e Y_c/N_c	Cp_o-Cp_e
2	2.32	0.033	0.043	—0.010
7	3.30	0.117	0.061	+0.056
7	4.67	0.117	0.087	+0.030
8	6.63	0.133	0.123	+0.010
20	9.40	0.333	0.174	+0.159
29	13.34	0.483	0.247	+0.236
34	18.91	0.567	0.350	+0.217
38	26.83	0.633	0.497	+0.136
50	38.06	0.833	0.705	+0.028
60	53.98	1.000	1.000	0.000
N=60	N_c=53.98			D=0.236

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.174	0.210	0.236	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 35. Chemistry sub-group at group 'B' level

Cf_o Y	Cf_e Y_c	Cp_o N/Y	Cp_e Y_c/N_c	Cp_o-Cp_e
2	2.35	0.033	0.028	+0.005
2	3.36	0.033	0.040	—0.007
5	4.80	0.082	0.058	+0.024
7	6.85	0.115	0.082	+0.033
10	9.79	0.164	0.117	+0.047
23	13.90	0.377	0.168	+0.209
28	19.99	0.459	0.240	+0.219
36	28.57	0.590	0.337	+0.253
43	40.83	0.705	0.490	+0.205
48	58.33	0.787	0.700	+0.087
61	83.35	1.000	1.000	0.000
N=61	N_c=83.35			D=0.253

Level of Significance of Goodness of Fit

Table Values of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.172	0.207	0.253	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

Table 36. Goodness of fit for biological sciences sub-group at group 'B' level

Cf_o Y	Cf_e Y_c	Cp_o N/Y	Cp_e Y_c/N_c	Cp_o-Cp_e
3	4.71	0.030	0.037	—0.007
7	6.54	0.072	0.052	+0.020
11	9.08	0.113	0.072	+0.041
14	12.62	0.144	0.104	+0.040
17	17.54	0.175	0.139	+0.036
28	24.36	0.289	0.193	+0.096
41	33.85	0.422	0.268	+0.154
54	47.02	0.557	0.373	+0.184
67	65.33	0.691	0.518	+0.173
81	90.76	0.835	0.720	+0.115
97	126.1	1.000	1.000	0.000
N=97	N_c=126.1			D=0.184

Level of Significance of Goodness of Fit

Table Valces of D		Observed	Level of Significance
0.05 Level	0.01 Level	D Value	of D[1]
0.139	0.166	0.184	* *

[1]* stands for significance at 0.05 level.
** stands for significance at 0.01 level.

The List of Publications of Assoc. Prof. Dr. A. Kemâl Özinönü

Translations:

1. **The Primary School Curriculum, İlkokul Müfredatı** By Roberty Dottrens, UNESCO, Paris, 1962.
2. **The Story of Eight Year Study, Sekiz Yıllık Araştırma Hikayesi** (Wilford M. Aikin, ed.,) Co-translator Lamia, Özinönü. M. E. Basımeci, İstanbul - 1952.

Scientific Rapers:

1. «Kavram Anlamı ve Kavram Gelişmesi» «Meaning of Concept and Concept Development» **Gazi Eğitim Enstitüsü Araştırmaları ve İncelemeleri** Bulletin No 2,March 1962 Ankara, pp. 88 - 93.
2. «Öğretmen Yetiştirmede Namızetlerin Seçimi - Selection Process of Prospective Teachers» **Gazi Eğitim Enstitüsü Araştırmaları ve İncelemeleri,** Bulletin No 1, June 1961.
3. «Financial Support For Science and Education In Turkey» - **Conference on Teaching of Science,** CENTO, Teheran 1963, Catholic Press, Beirut, Lebanon pp. 29 - 51.
4. «Pattern of Scientific Development in Turkey; 1933 - 1966». **Science and Technology in Developing Countries,** Cambridge University Press (It is published). pp. 144 - 178 and pp. 563-569, May 1969.
5. «Visit to a Turkish High School» **The Clearing House,** Co-author Lamia Özinönü, Sept, 1956, Vol. 31, No. 1 pp. 11 - 14.
6. «Temel Eğitim Sorunlarımız ve Bunların Çözümlenmesinde Üniversitelerimizin Katkısı - Basic Issues of Turkish Education and The Contributions of Universities in Their Sotutions», **Yurtiçi Konferansları** (Turkish) M.T.E.U. 1967 pp. 71 - 80.
7. Fen Öğretiminin Bilimsel Düşünmeyi Geliştirmesi - Adapting Turkish Secondary Science Education to Reinforce Scientific Thinking» **Orta Öğretimde Fen Öğretimi Simpozyumu** (Turkish), Türkiye Bilimsel ve Teknik Araştırma Kurumu, Scientific and Technological Research Council of Turkey - Ankara, 1969, pp. 21 - 39.
8. «Bilimsel Düşünme Kabiliyetinin Gelişmesinde Lise Fen Öğretiminin Rolü The Role of High School Science Education on the Development of Scientific Thinking Ability» - **Research Report** present to Turkish Scientific and Technological Council, Ankara, 1967. (Co researcher Assoc. Prof. Dr. Cemal Yıldırım).
9. Since 1967 eight Newspaper articles and more than ten editorials written on education, science education and science policy were published in YENİ GAZETE (New Gazette), Istanbul-Turkey.
10. Up to ten articles were published in Turkish Leading Journals such as **Forum, Yarın, İnsangücü ve Eğitim** and one article in **Turkish Elementary** Science Education Journal in **Elementary Education** (Turkish).